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Opportunities and challenges for small-scale aquaculture in Zambia

Alexander Kaminski, Mara Gellner, Dominik Giese, Sharif Jabborov, Mario Lootz, Mary Lundeba, Boniface Nyika, Nicolas Patt, Azin Sadeghi, Muzamba Siachinga

2019

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Seminar für Ländliche Entwicklung | Centre for Rural Development

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SLE Postgraduate Studies on International Cooperation for Sustainable Development

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Study in cooperation with
Advisory Service on Agricultural Research for Development (BEAF) of the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) in cooperation with the CGIAR Research Program on Fish Agri-Food Systems (FISH) led by WorldFish

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Preface

For more than 55 years, the Centre for Rural Development at the Humboldt-Universität zu Berlin has annually trained 20 postgraduates to become professionals equipped with excellent knowledge and skills in the field of German and international development cooperation.

Three-month empirical research projects conducted in cooperation with German or international development agencies form an integral part of this one-year course. Participants work in interdisciplinary teams supervised by experienced team leaders and carry out innovative, future-oriented research on development problems that prevail on the ground on a local or national scale. This strengthens global knowledge and provides partner organisations in the host country with strategies and tools. Here it is vital to involve a wide range of actors in the process, which includes surveys and consultations at household, expert and policy level.

Most studies are linked to rural (or urban) development themes and have a socio-economic focus, such as the enhancement of agricultural livelihoods or the design of regimes to manage natural resources sustainably. Up to now, our partner countries have either been developing or transformation countries, and occasionally fragile states. In the future, however, studies will also be conducted in the global north, since the Sustainable Development Goals (SDGs) are global concerns. New methodologies have been introduced in some studies, e.g., production of handbooks or guidelines. Further priorities are evaluations, impact analysis and participatory planning. In these cases the respective host country serves as a test region.

Throughout the years, SLE has carried out more than 200 cooperation projects in over 90 countries. The results are published in this series.

The present study on small-scale aquaculture in Sambia was carried out in cooperation with the Advisory Service on Agricultural Research for Development (BEAF) and the CGIAR Research Program on Fish Agri-Food Systems (FISH).

We wish you a stimulating read.
Yours sincerely,

Prof. Dr. Bernhard Grimm
Dean of the Faculty of Life Sciences
Humboldt-Universität zu Berlin

Dr. Susanne Neubert
Director of the Centre for Rural Development (SLE)

Acknowledgements

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We are indebted to Dr. Sloans Chimatiro and WorldFish for accommodating the research team for three months in Lusaka and providing logistical support and expertise. Specifically, we thank Silke Uhlenbrock, Dr. Sven Genschick and Dr. Steve Cole for their guidance, as well as the two WorldFish drivers, Felix Luwawa and Chrispin Chikani.

We also thank Moritz Heldmann, the Project Coordinator of the GIZ SEWOH programme in Zambia, for accommodating us in Eastern Province and for ensuring that the information in this project is utilised for further development cooperation between Germany and Zambia.

We thank all the stakeholders and key informants for their expert advice and knowledge in providing the context for this project.

Two aquaculture consultants, Dr. Stefan Holler and Dr. Wiza Ng'ambi, are also thanked for their invaluable contributions to the additional study in Eastern Province.

Finally, and most sincerely, we express our gratitude to all the farmers who graciously invited us into their homes and contributed to this study. We hope this research expands the body of knowledge on small-scale fish farming in Zambia and is used by stakeholders to make meaningful contributions to the enhancement of the sector.

Executive summary

The Seminar für Ländliche Entwicklung (SLE) also known as the Centre for Rural Development provides a one-year training programme on international development for master graduates from different disciplines and backgrounds. Part of the programme involves collaborating with research partners and international organisations to develop a short-term research and development project. This report is a culmination of a six-month study that took place between June and November 2018. A team of seven researchers from SLE, based at Humboldt University, set out to assess the opportunities and challenges faced by small-scale fish farmers in Zambia. The team sought additional support from four Zambian researchers and several government extension officers. This study, funded by the German government and in partnership with an international research institute as well as the government department responsible for fish farming in Zambia, collected quantitative and qualitative data that aimed to provide a holistic view of the livelihoods of smallholder fish farmers in the country. A total of 151 fish farming households were surveyed and an additional 46 qualitative interviews were collected with a selected variety of fish farmers. The results were disseminated to Zambian stakeholders at a seminar in Lusaka in October 2018, and presented again at Humboldt University in Berlin and again at the GIZ Head Office in Eschborn in November. This report sets out the following broad findings and recommendations:

- There is a severe lack of reliable information on small-scale fish farming in Zambia, making it difficult to characterise and engage with the sector, particularly from the viewpoint of international development.
- Fish farming households and systems are diverse, falling between two categories: 'semi-subsistence' and 'small-scale commercial'. However, the wealth, location, gender and age of farmers highlight other sub-groups of farmers who are not always acknowledged, each facing their own challenges and opportunities.
- Fish farming is a livelihood diversification strategy employed by rural poor farmers who generally struggle to produce large yields of fish. Almost two thirds of the sample produced less than 0.1 tonnes (t) of fish in 12 months. The remaining farmers who produced between 0.1 and 2 t scored higher on the asset index on average than rural poor farmers.
- To some extent, wealth is correlated with the performance of fish farmers, with wealthier farmers owning more intensive systems and generally producing larger volumes of fish. However, this is not always a definitive fac-

tor, and gaps in the supply chain as well as a lack of knowledge and skills mean that even wealthier and more commercial farmers face production challenges.

- Almost none of the farmers were primarily fish farmers but rather they had other livelihood strategies that provided their main income. This perspective on broader livelihood strategies must be acknowledged when assessing 'fish farmers' in Zambia.
- There were not many female or young farmers (<35 years old), and those that were captured in the sample generally had lower asset bases and smaller production volumes.
- While we did not find many female 'fish farmers', women undoubtedly participated in gendered fish farming activities within male-headed households. The women who were in charge of fish farming or resided in female-headed households still had to rely on men (or external labour) to perform certain fish farming activities.
- There were few incentives for youths to enter into aquaculture in rural areas given that fish farming was rarely seen as a high-income generating activity.
- Despite the growing availability of commercial inputs for aquaculture (e.g. feed and seed) in the country, most fish farmers still struggle to access these products.
- More than two thirds of fish farmers stated that they engage in fish farming primarily as an income-generating activity. At the same time more than three quarters of farmers stated that they still consume fish from their ponds, suggesting that although people mainly aim to sell fish for income, the ponds also play a role in household fish consumption.
- Many fisher farmers realize small profit margins due to the constraints in training and accessing inputs. Some farmers require large start-up capital to get into fish farming, especially in drier areas. It is critical to calculate the non-cash value of labour and fish consumed within the household, as these are two key characteristics of smallholder fish farming in Zambia.
- There is an interesting geographic divide in the aquaculture landscape, with thousands of poorer fish farmers residing in the north, growing indigenous tilapia species with extensive systems and relatively low total production volumes, while only a few hundred, generally wealthier fish farmers, with more intense systems and higher production volumes, operate in the south of the country. This does not mean that people in the south are generally wealthier, just that getting into fish farming requires higher capital de-

mands because of the environmental conditions (i.e. less rainfall and drier soils). The conditions in the north seem to be more favourable for aquaculture development, although the proximity and access to the supply chain and markets are generally better in the south. In the south, farmers are also permitted to grow non-native, fast-growing tilapia species.

- In general it is proposed that a livelihood perspective should be considered when characterising fish farmers in Zambia. First the wealth, location, gender and age of farmers should be used to profile and create different farming groups, each of which has its own unique challenges and opportunities. Second, interventions should focus on production, livelihood, value chain or household levels, the last-mentioned referring to complex sociocultural relationships and dynamics within and between households. Ideally, a mixture of interventions should be assessed across these levels. Interventions can be of a technical nature or seek to challenge certain harmful social norms that create barriers for marginalised groups. Interventions should consider both these factors for optimal development impact. Several practical ideas are highlighted at the end of this report, where the emphasis is on the inclusion of poor farmers, including especially women and youths.

Zusammenfassung

Das Seminar für Ländliche Entwicklung (SLE) an der Humboldt Universität zu Berlin bietet Teilnehmer*innen mit Masterabschlüssen unterschiedlicher Fachrichtungen ein einjähriges Training zur Internationalen Zusammenarbeit an. Ein Teil des Programms besteht aus einer praktischen sechs monatigen Forschungsarbeit in Zusammenarbeit mit Partnern aus der Forschung und internationalen Organisationen. Der vorliegende Bericht ist das Ergebnis einer Studie aus 2018, die zwischen Juni und November in Berlin und Sambia erarbeitet wurde. Ein sieben köpfiges Team evaluierte die Chancen und Herausforderungen von kleinbäuerlichen Fischfarmer*innen in Sambia. Beauftragt wurde die Studie von der Einheit „Beratung für entwicklungsorientierte Agrarforschung" der Gesellschaft für internationale Zusammenarbeit (BEAF/GIZ). Partner der Studie war das internationale Forschungsinstitut WorldFish und das sambische Fischereiministerium. Das Team wurde zusätzlich von vier sambischen Forscher*innen und mehreren staatlichen Landwirtschafsberater*innen unterstützt. Um einen umfassenden Einblick in die Lebensgrundlagen *Livelihood* der kleinbäuerlichen Fischfarmer*innen zu erhalten, wurden quantitative und qualitative Daten erhoben. Insgesamt wurden die Daten aus Fragebögen von 151 Aquakultur betreibenden Haushalten ausgewertet und zusätzlich wurden 46 qualitative Interviews mit ausgewählten Fischfarmer*innen durchgeführt. Die Ergebnisse wurden den sambischen Interessenvertreter*innen im Oktober 2018 in Lusaka präsentiert und der interessierten Öffentlichkeit in Deutschland an der Humboldt Universität im November. Zusätzlich wurden die Ergebnisse den Mitarbeiter*innen des Auftragsgebers GIZ in Eschborn vorgestellt. Der vorliegende Bericht beinhaltet folgende Ergebnisse und Empfehlungen:

- Es gibt wenig zuverlässige Informationen über den kleinbäuerlichen Aquakultursektor in Sambia. Dies erschwert es internationalen Geberorganisationen die Besonderheiten von Fischfarmer*innen als Zielgruppe zu berücksichtigen und sich in dem Sektor zu engagieren.
- Es gibt große Unterschiede zwischen Fischfarmer*innen in Sambia, sowohl was die Merkmale der Haushalte angeht, als auch der Aquakultursysteme. Unseren Ergebnissen zufolge kann man sie zwischen den Kategorien halb Subsistenz und kleinskalig kommerziell einordnen. Andere Faktoren, die für eine Einteilung wichtig sind, sind Vermögen, Standort, Gender und das Alter. Jeder Faktor besitzt dabei eigene Möglichkeiten und Herausforderungen.

- Aquakultur wird von ärmeren Farmer*innen im ländlichen Raum als eine Diversifizierungsstrategie betrieben. Die meisten von ihnen haben Schwierigkeiten große Mengen an Fisch zu produzieren. Annähernd zwei Drittel der befragten Farmer*innen ernteten weniger als 0,1 Tonne (T) innerhalb von 12 Monaten. Farmer*innen, die zwischen 0,1 und 2 T Fisch ernten konnten, hatten durchschnittlich mehr Punkte auf dem Asset Index.
- Zum Teil beeinflusst Vermögen die Ertragsleistung von Fischfarmer*innen. Wohlhabendere Farmer*innen betreiben intensivere Systeme und produzieren mehr Fisch. Trotzdem ist dies nicht immer der Fall, da sowohl unzureichende Lieferketten, als auch Wissenslücken und fehlendes Training dazu beitragen, dass auch wohlhabendere und kommerziellere Farmer*innen Produktionsschwierigkeiten haben können.
- Fast keiner der befragten Farmer*innen war ausschließlich auf Aquakultur spezialisiert, sondern hatte mindestens eine andere Haupteinnahmequelle. Dieses Merkmal der diversen Einkommensquellen ist wichtig, wenn man von Fischfarmer*innen in Sambia spricht.
- Nicht viele Frauen und Jugendliche (unter 35 Jahren) betreiben Aquakultur. Diejenigen, die Fische produzieren, sind – im Vergleich zu älteren, männlichen Farmern - weniger wohlhabend und produzieren weniger Fisch.
- Obwohl nicht viele Frauen hauptverantwortlich Aquakultur betreiben, so sind die Ehefrauen von Fischfarmern auf Haushaltsebene zweifelsohne bei Aquakulturtätigkeiten involviert. Frauen, die allein für die Aquakultur verantwortlich sind (z.B. weil sie den Haushalt alleine führen), sind für bestimmte Aktivitäten trotzdem auf die Hilfe von Männern (z.B. angestellte Arbeiter) angewiesen.
- Es gibt wenig Anreize für Jugendliche im ländlichen Raum Aquakultur zu betreiben, da Aquakultur nur selten als eine attraktive Möglichkeit zur Einkommensgenerierung gesehen wird.
- Obwohl die Verfügbarkeit von kommerziellen Produkten für Aquakultur (z.B. Fischfutter und Fischbrut) in Sambia weiter ansteigt, haben die meisten kleinbäuerlichen Fischfarmer*innen Probleme diese Produkte zu erlangen.
- Mehr als zwei Drittel der befragten Farmer*innen gaben an, dass sie Aquakultur hauptsächlich als Einkommensstrategie betreiben. Zugleich sagten mehr als Dreiviertel aller Farmer*innen, dass sie den Fisch aus ihren Teichen regelmäßig essen. Dies lässt darauf schließen, dass Aquakultur eine Rolle in der Haushaltsernährung spielt, selbst wenn die Farmer*innen auf einen Verkauf abzielen.

- Viele Farmer*innen erwirtschaften nur kleine Gewinnspannen, vor allem weil es an Training und Zugang zu spezifischen Produkten mangelt. Vor allem in trockeneren Gebieten benötigen Farmer*innen ein großes Startkapital, um mit Aquakultur zu beginnen. Für Deckungsbeitragsrechnungen ist es wichtig auch den zahlungsunwirksamen Wert (Arbeitskraft und konsumierter Fisch) zu berechnen, da dies zwei wichtige Kriterien der kleinbäuerlichen Aquakultur in Sambia sind.
- Es gibt eine interessante geographische Teilung der Aquakulturlandschaft in Sambia. Im Norden betreiben tausende, wenig wohlhabenden Farmer*innen Aquakultur mit einheimischen Tilapia Arten in extensiven Systemen mit einer relativ geringen Produktivität. Im Süden produzieren einige hundert, allgemein wohlhabendere Fischfarmer*innen in intensiveren Systemen höhere Erträge. Das bedeutet nicht, dass die Bevölkerung im Süden generell reicher ist. Allerdings ist in dieser Region aufgrund der Umweltgegebenheiten (z.B. Regenmenge, Böden), ein höheres Startkapital nötig, um Fischteiche zu bauen und zu betreiben. Die Umweltbedingungen im Norden hingegen scheinen günstiger für die Entwicklung der Aquakultur zu sein, jedoch fehlt hier – im Vergleich zum Süden - die Nähe und der Zugang zu Lieferketten und Märkten. Außerdem ist im Süden die Verwendung einer nicht-einheimischen, schnell wachsenden Tilapia Art erlaubt.
- Allgemein sollte die gesamte *Livelihood* von Farmer*innen betrachtet werden, wenn man sich ein Bild von Fischfarmer*innen in Sambia machen möchte. Als erstes sollten Vermögen, Standort, Gender und Alter von Farmer*innen zur Einteilung genutzt werden, da jeder Faktor eigene Herausforderungen und Möglichkeiten beinhaltet. Zweitens sollten Interventionen auf die Ebenen Produktion, *Livelihood*, Wertschöpfungsketten oder Haushalt fokussieren. Die Haushaltsebene beinhaltet komplexe soziokulturelle Beziehungen und Dynamiken innerhalb und zwischen Haushalten. Idealerweise sollte ein Mix aus Interventionen innerhalb dieser Ebenen angestrebt werden. Interventionen können technischer Natur sein und/oder versuchen schädliche soziale Normen anzugehen, die marginalisierte Gruppen ausgrenzen. Es ist wichtig, dass Interventionen verschiedene Faktoren und Ebenen für eine optimale Wirkung berücksichtigen. Am Ende des Berichts zeigen mehrere praktische Ideen, wie die Teilhabe von nicht wohlhabenden Farmer*innen, insbesondere Frauen und Jugendlichen, gelingen kann.

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Abbreviations

AfDB	African Development Bank
AgriFood	Agriculture and Food Security
BEAF	Advisory Service on Agricultural Research for Development
BMZ	German Federal Ministry for Economic Cooperation and Development
CGIAR	Consultative Group on International Agricultural Research
CRP FISH	CGIAR Research Programme on Fish
DFID	Department for International Development
DoF	The Department of Fisheries of the Zambian Ministry of Agriculture and Livestock
FANSER	Food and Nutrition Security, Enhanced Resilience
FAO	Food and Agricultural Organization
FGD	Focus Group Discussion
GIC	Green Innovation Centres for Agricultural and Food Sector
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GMA	Gross Margin Analysis
HH	Household
NGO	Non-governmental Organizations
SADC	Southern African Development Community
SD	Standard Deviation
SDG	Sustainable Development Goals
SEWOH	Initiative "One World – No Hunger"
SLA	Sustainable Livelihood Analysis
SLE	Centre for Rural Development
TLU	Tropical Livestock Unit
VCA	Value Chain Analysis
ZAEDP	Zambian Aquaculture Enterprise Development Programme
ZMW	Zambian Kwacha

1 Study context

1.1 Background and problem statement

Zambia has around 15 million hectares of water in the form of inland rivers, lakes and swamps, which provide the natural resources needed for fish production. Capture fisheries in Zambia still provide the majority of fish – over 80,000 tonnes (t) in 2014 – although production has stagnated in the last decade. Aquaculture contributed close to 20,000 t in that year, roughly 20 % of the total supply (see Fig. 1). An additional 55,000 t was imported into Zambia to fill the fish supply deficit in the same year (Kaminski et al. 2018). Fish supply per capita in Zambia has been steadily increasing in recent years, thanks in part to significant contributions from aquaculture and imports. Most notably, aquaculture has been rapidly growing: Zambia is the largest aquaculture producer in the Southern African Development Community (SADC) and the sixth largest producer in Africa (Food and Agriculture Organization (FAO), 2016).

In the years between 2009 and 2014, aquaculture production almost tripled (Kaminski et al. 2018a). The bulk of this production came from the commercial expansion of large-scale, capital-intensive enterprises, namely from investments in cage culture and the intensive land-based production of tilapia. These commercial producers sprang up in certain high potential zones in the country. While the commercial sector was relatively small prior to 2009, by 2018 it produced over 80 % of the total fish yield from aquaculture, made up almost entirely of tilapia (Kruijssen et al. 2018a). This surge in production of mostly tilapia species has primarily been achieved through significant value chain upgrades in the supply chain (*i.e.* feed factories and imported fish strains) and output markets (*i.e.* cold chains) (Kaminski et al. 2018). Evidence from a WorldFish study in 2017 shows that production from the small-scale sector has not increased in tandem with the growth seen in the commercial sector, and that rural farmers located outside aquaculture production zones are at risk of becoming isolated from developments in the value chain (Genschick et al. 2017). Small-scale farmers struggle to produce high yields due to problems with accessing key inputs and services and reaching high-value markets. There is little policy or development advice for these farmers, partly due to the fact that there is little information about the small-scale sector.

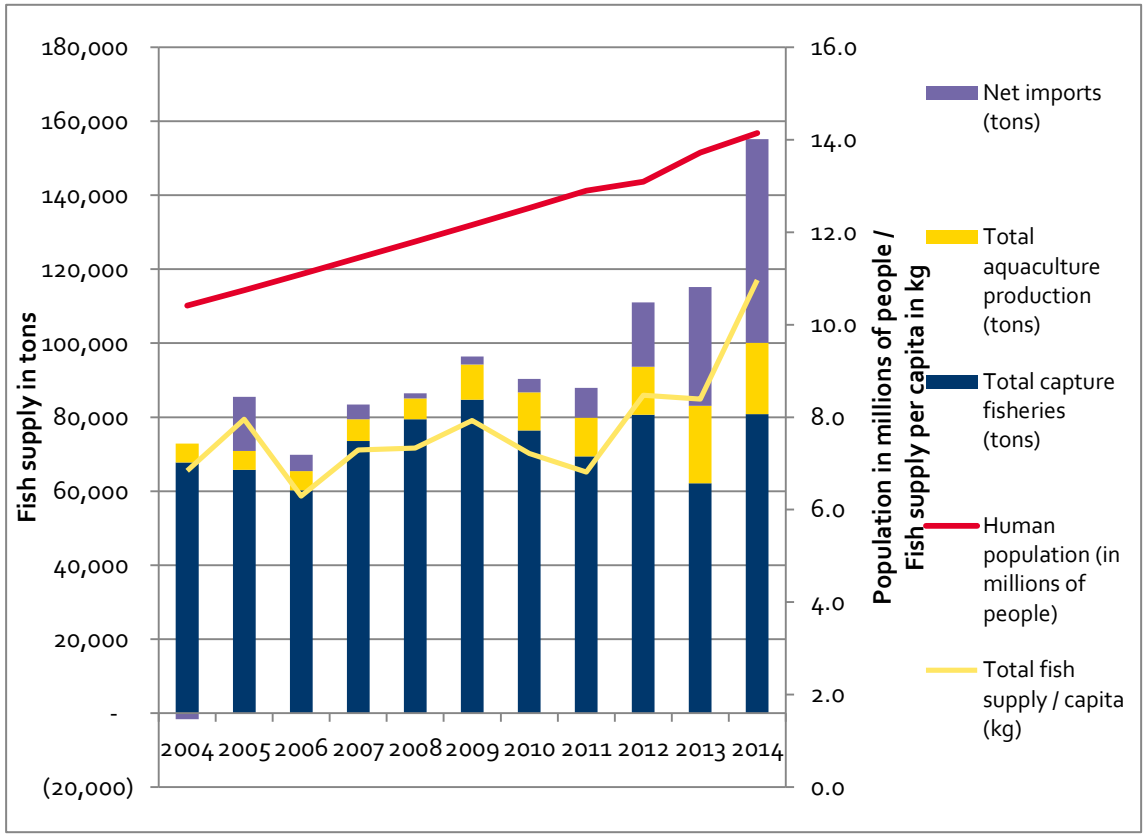

Figure 1: Fish production and supply per capita (2004-2014)

Source: Kaminski et al. 2018.

A value chain study by Kruijssen et al. (2018a) confirms that there is a major problem with defining the sector and devising development strategies that are appropriate to different farming systems and concurrent livelihoods. The same study attempts to show the vast disparity between small-scale and commercial productivity, although there is still a lack of research on the small-scale sector. A study by Kaminski et al. (2018) shows that small-scale farmers produce small amounts of fish, mostly for household consumption, and that only 8 % of smallholder farmers from the sample conduct fish farming as a primary income-generating activity. Most of these farmers who are located in the Northern Province of Zambia have little access to high-quality sources of feed and seed. While there has been an increase in commercial activity in the south of the country (Southern and Lusaka Provinces), little is known about the 'spillover' effects[1] this has on smallholder farmers. According to government statistics, there are almost

[1] The intended or unintended effects of industrial and commercial development.

ten times fewer fish farmers in Southern and Lusaka Provinces than in Northern Province, although productivity in the southern region is shown to be higher (Department of Fisheries (DoF) 2015).

It is believed that greater coordination (*e.g.* contract and/or cluster farming) and greater participation in the value chain (accessing and acquiring inputs, services and markets) could help farmers increase production and improve their productivity, thereby increasing incomes and overall food and nutrition security (Genschick et al. 2017). It is unclear, however, what the capacities of these farmers are and what role fish farming plays in household livelihoods, especially the participation of women and young people. There is very little data on the production systems of small-scale farmers and how fish farming fits into the larger agricultural plans of households.

An analysis of the economic, social and biophysical (*i.e.* agro-ecology of production systems) contexts is therefore necessary to identify opportunities and challenges and provide small-scale farmers with recommendations on how to intensify production sustainably and develop equitable opportunities in the value chain.

1.2 Cooperating partners

The Advisory Service on Agricultural Research for Development (BEAF) of the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) commissioned this study led by the Seminar für Ländliche Entwicklung (SLE). The SLE team comprised a team leader and six junior researchers who specialise in various fields, as well as two Zambian research associates and three independent consultants (see Annex 1). There were several cooperating partners, including WorldFish, the Department of Fisheries (DoF) and GIZ Zambia, who provided support and assistance in the project's implementation (see Annex 1).

- **WorldFish - Consultative Group for International Agricultural Research (CGIAR)**

WorldFish is an international non-profit research organisation that promotes fisheries and aquaculture research for poverty alleviation. The WorldFish office in Zambia plays a coordinating role for the Africa region in the implementation of the new CGIAR Research Programme on Fish (CRP FISH). WorldFish hosted the SLE Research Team and worked closely on data collection to help identify development strategies that aim to improve farmers' livelihoods. WorldFish currently runs several projects in Zambia targeting smallholder farmers. The interest in this

study for WorldFish was to collect in-depth data on farmers' livelihoods. Working with SLE, WorldFish developed the initial concept for the study, which was subsequently funded by GIZ.

- **The Department of Fisheries (DoF) in the Ministry of Fisheries and Livestock of the Government of the Republic of Zambia (GRZ)**

The Department of Fisheries is primarily responsible for servicing and guiding the fisheries and aquaculture sectors in Zambia. In 2017, the DoF launched the Zambian Aquaculture Enterprise Development Programme (ZAEDP), financed with a $40 million loan from the African Development Bank (AfDB). This programme aims to develop the entrepreneurial capacity of small-scale farmers by creating an enabling environment through infrastructure development, training and policy implementation, which allows small-scale farmers to make further linkages with private sector actors. A key goal of the programme is the establishment of so called "aqua-parks" that operate as aquaculture development zones. Smallholder farmers are clustered in these areas and the private sector is incentivised to engage with them. The DoF was a key research partner in the implementation of the study because it aimed to identify sustainable and cost-effective implementation strategies for the ZAEDP. The sample in this study included one of the proposed "aqua-park" sites.

- **The Deutsche Gesellschaft für Internationale Zusammenarbeit – German Corporation for International Cooperation GmbH (GIZ)**

Two units from GIZ were involved in this study. The first was the Advisory Service on Agricultural Research for Development (BEAF), which funds research on sustainable agriculture in developing countries. BEAF, on behalf of the German Federal Ministry for Economic Cooperation and Development (BMZ), was the primary funder of this study. The second unit was the Agriculture and Food Security (AgriFood) Programme of GIZ Zambia, which is implementing the BMZ flagship initiative "ONE WORLD – No Hunger" programme (SEWOH). GIZ is currently implementing three SEWOH components in Zambia under their AgriFood Programme. They are also exploring the possibility of including a fisheries and aquacultures component in their SEWOH activities and thus asked the SLE team to lead a scoping study on the potential for fish production in Zambia, particularly in Eastern Province where they operate.

1.3 Study locations

This study took place in four provinces in Zambia. The main study comprises data from Northern, Lusaka and Southern Provinces, while an additional study was undertaken with GIZ in Eastern Province. The aquaculture landscape differs significantly between the north, south and east regions (Genschick et al. 2017). The majority of smallholder fish farmers are found in the north of the country, while the larger, more market-oriented aquaculture producers are located in the central and southern areas of Zambia. Less is known about the eastern region in terms of aquaculture and fisheries production. The regions vary considerably in their socioeconomic and ethnic contexts. The inclusion of diverse areas in the sample allowed for comparisons of various social, economic and environmental factors. Such an improved understanding of the small-scale sector as a whole provided an opportunity to gain insights into the challenges and opportunities faced by fish farmers throughout the country.

1.3.1 Northern Province

Northern Province is home to the largest number of small-scale fish farmers (DoF 2015). It is estimated that there are 2,436 registered fish farmers in Northern Province, with a total production of 797.04 t in 2014 (DoF 2015). The significant density of small-scale fish producers can be attributed to the abundance of available perennial water sources and higher rainfall compared to the rest of the country. Aquaculture production in Northern Province is generally characterised by small-scale, resource-poor farmers who mainly practise fish farming for subsistence or to make a small contribution to household income (Genschick et al. 2017). A study conducted by Nsonga (2015) indicated that the average fish production of small-scale farmers from a sample in Northern Province is approximately 2 tonnes per hectare (t/ha). A more recent study estimates average productivity to be around 1.06 t/ha (Kaminski et al., 2018). Although Northern Province has higher total production levels compared to regions such as Lusaka, the productivity per hectare is lower. Nsonga (2015) states that most farmers in the area face input-related issues such as a lack of access to quality fingerlings[2] and affordable feed[3], as well as constrained mobility in accessing markets. The Misamfu Aquaculture Research Station is the only major government-run seed provider in Northern

[2] These are juvenile fish that grow into larger adults for selling and consumption (sometimes also referred to as 'seed').

[3] In this case 'feed' refers to home-made, store-bought or manufactured feeds consumed directly by fish.

Province and, for reasons of biosecurity, is limited to disseminating indigenous tilapia species (Genschick et al. 2017).

1.3.2 Southern and Lusaka Provinces

The south of Zambia is home to large, commercial producers such as Kafue Fisheries Ltd. located by the Kafue Flats in Lusaka Province, and two large cage culture companies by Lake Kariba in Southern Province (Yalelo and Lake Harvest Ltd.). Several other commercial producers, hatcheries and feed companies are located in these two provinces. This represents the stronghold of commercial aquaculture production in Zambia (Genschick et al. 2017). The commercial sector is largely flourishing in Lusaka and Southern Provinces, referred to in the present study as 'the south' or 'southern region' of the country. One of the main reasons for this surge in commercial and intensive production in the south includes the permission to cultivate non-native Nile Tilapia (*Oreochromis niloticus*), which is banned in the rest of the country for biosecurity reasons, as well as the proximity of producers to major urban markets (Kaminski et al. 2018). However, little is known about whether or not the small-scale sector in this province benefits from commercial activities and the seemingly growing enabling environment. According to DoF statistics, there are only 207 and 255 small-scale fish farmers in Southern and Lusaka Provinces respectively (DoF 2015), about a tenth of the farmers found in Northern Province.

1.4 Eastern Province

Eastern Province is not typically known as a highly productive region in terms of aquaculture, mostly due to low rainfall and the poor availability of water bodies compared to the north of Zambia. DoF statistics report that there are 1,533 small-scale fish farmers cultivating indigenous three-spotted tilapia (*Oreochromis andersonii*). A considerable number of reservoirs have also been established in Eastern Province (Kruijssen et al. 2018a). An additional component of this study used a brief scoping methodology to identify possible opportunities and challenges for promoting fish farming in Eastern Province, including the potential for increasing access to fish products for consumption. The scoping study is only summarised in this report but can be found as a separate SLE publication under the title *"The potential for reservoir fisheries and aquaculture in Eastern Province, Zambia"* (Gellner et al. 2019).

2 Research design

This chapter outlines the research framework of the study, including the research objectives, the Theory of Change (ToC) and the guiding research questions.

2.1 Research objectives

The overall objective of this study was to assess and analyse the role of fish farming in the livelihoods of farmers who operate various small-scale farming systems, taking the surrounding social, economic and biophysical factors into consideration. The study aimed to identify the key livelihood systems of fish farmers and how they were interlinked with productions systems, what role fish farming plays in household livelihoods, the opportunities and challenges of smallholders' participation in value chains, the profitability of small-scale fish farming, and the constraints and opportunities for women and young people to participate in fish farming. Using the information provided in the report, development and research institutions such as WorldFish and GIZ, as well as government departments can gain greater insight into the livelihoods and capacities of fish farming households. By having a greater understanding of the sector and a clearer characterisation of the existing aquaculture systems and livelihoods of smallholder fish farmers, development strategies can be tailor-made to fit different contexts.

2.2 The Theory of Change of the project

The project's ToC is shown in Figure 2. It shows the roadmap of the project and illustrates how activities carried out in the study can ultimately lead to certain outcomes and the overall development impact. A comprehensive overview of the project's main activities, seen at the bottom of the ToC illustration (Fig. 2), is presented in the Methodology section in Chapter 4.

The research activities were designed to collect data for three main outputs that were framed as assessments:

Output 1: An assessment of the asset endowments and farm characteristics of fish farming households, including the role of fish farming in household livelihood systems

Output 2: A value chain analysis and gross margin analysis of small-scale fish farming systems

Output 3: A gender-differentiated analysis of intra-household labour division and the participation of youths in fish farming

Output 4: A scoping study in Eastern Province (published as a separate report).

The results presented in these outputs were then combined to develop tailor-made recommendations that specifically suit the different small-scale aquaculture contexts observed in the study (see Chapter 7). The main outcome is that different development organisations, donors, government and/or private sector actors can adopt these strategies and recommendations in their plans and activities. This will ultimately assist male and female farmers to sustainably, inclusively and profitably engage in fish farming, thus contributing to improved livelihoods and overall food and nutrition security as the main impact. This development impact is in line with the United Nations' Sustainable Development Goals.

2.3 Research questions

To achieve the research objectives, the study was guided by research questions oriented to the three outputs presented.

The following research questions guided the development of Output 1, which focused on the household livelihood level:

- What key livelihood assets do fish farming households have and how does this relate to production systems and performance?
- What is the role of fish farming in household livelihood strategies?

Output 2 explored the economic context by asking:

- What challenges exist in value chain participation and how profitable is fish farming?

Output 3 aimed to explore social issues and the research question was framed as:

- What are the constraints and opportunities women and young people face in small-scale fish farming?

Image 1-4: Semi-subsistence ponds [top left], small-scale commercial ponds [top right], tilapia harvested in a bucket [bottom left], small-scale cage [bottom right]

Photos: A. Sadeghi & S. Jabborov

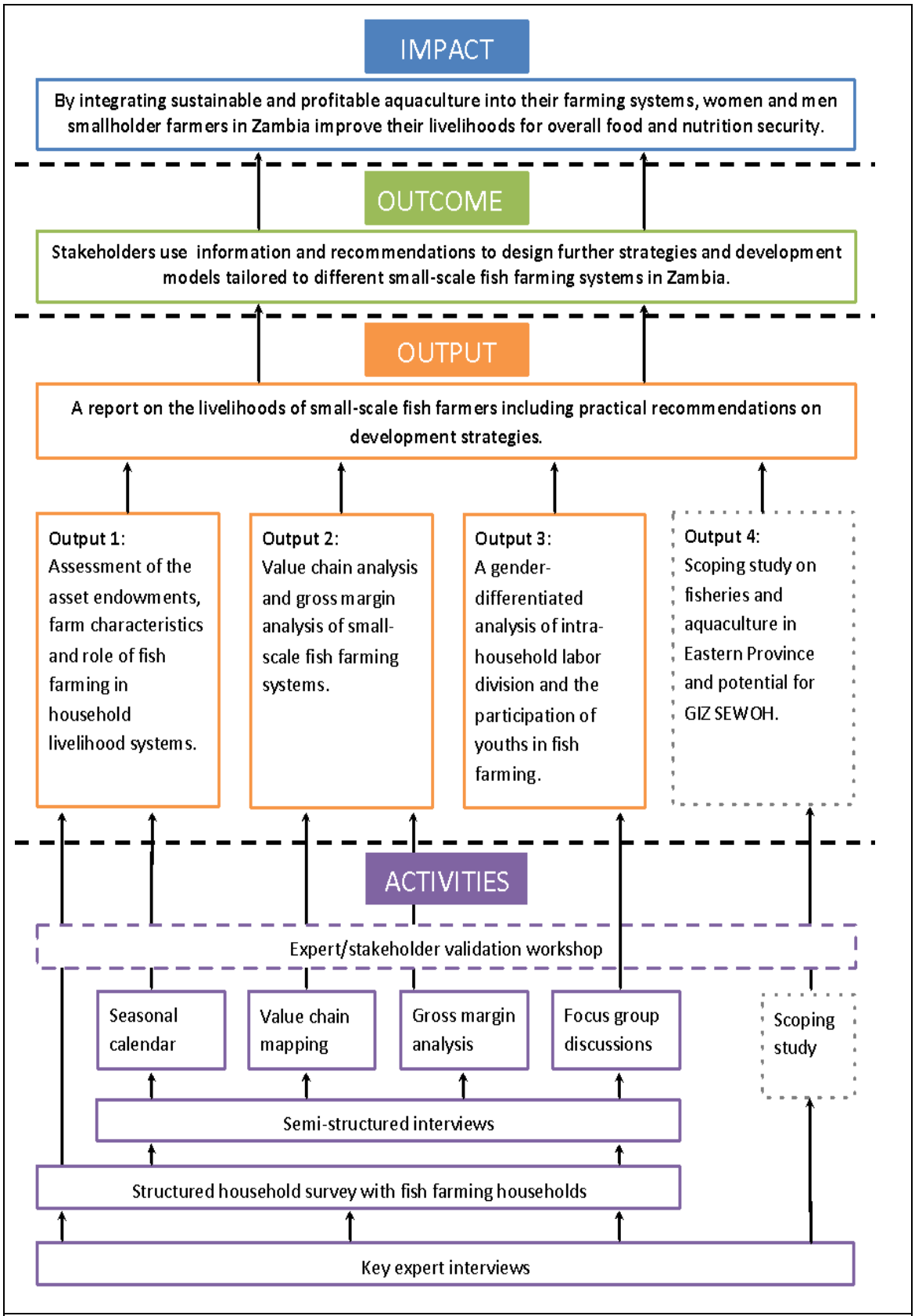

Figure 2: Theory of Change of the project

Source: own illustration

Summary of additional Eastern Province Study (Output 4)

The potential for reservoir fisheries and aquaculture in Eastern Province, Zambia (Gellner et al. 2019)

The GIZ "ONE WORLD – No Hunger" (SEWOH) programme aims to assess the potential for small-scale fish farming and fisheries in Eastern Province. A small team comprising two consultants and an SLE junior researcher travelled to four districts in Eastern Province for two weeks in August 2018. The team interviewed 57 consumers (15 women, 42 men) using a food insecurity experience scale (FIES). A further seven key-informant interviews were undertaken with DoF staff and government hatcheries, thirteen semi-structured interviews were conducted with small-scale fisher farmers, and focus group discussions were held with three dam management committees and two farming cooperatives.

Aquaculture production is scarce in the province due to there being very few perennial water sources compared to other areas of Zambia. The study found that fish farmers were less food insecure than non-fish farmers, although poor, rural farmers were regarded as *'severely food insecure'* in general. Aquaculture was not a large part of the agricultural and economic activities in communities. Fish consumption was generally quite low compared to other areas. Fish farming was a secondary activity, with farmers producing fish mostly for home consumption. The greatest potential for aquaculture in Eastern Province lies in the numerous small water bodies that operate as small irrigation dams. Dam-based fisheries (involving artificial stocking) can be promoted to restock dams and manage them like small-scale fisheries. The potential for increasing food and nutrition security from dam-based fisheries is greater than that of small-scale aquaculture in ponds.

Image 5-6: A dam invaded by water hyacinth [left] and small nutritious fish caught using a hand-line [right]

Photos: M. Gellner

3 Guiding concepts and approaches

To address the study's different outputs and research questions, several theoretical concepts and approaches were used. The different approaches complemented and informed one other, resulting in a comprehensive analysis of the small-scale aquaculture sector.

3.1 Sustainable livelihood approach

The sustainable livelihood approach (SLA) promoted by the United Kingdom's Department for International Development (DFID) in the late 1990s is a mainstream approach for framing poverty alleviation (de Haan 2012). It primarily focuses on understanding the capacities and actions of a household (or actor) based on an analysis of their livelihood system (DFID 1999). Livelihood assets (or capitals), structures and processes influencing the livelihood system, strategies and overall outcomes, as well as the interrelations between these aspects, are assessed under this approach (see Fig. 3). At the centre of the analysis, the livelihood pentagon defines the livelihood assets of an actor, household or community, which is formulated under the five main 'capitals': human capital (*e.g.* knowledge), natural capital (*e.g.* land, water), financial capital (*e.g.* income), social capital (*e.g.* relationship with neighbours) and physical capital (*e.g.* production equipment) (Rauch, 2009). While the sustainable livelihoods approach can also focus on the vulnerability context and livelihood outcomes, as seen in Figure 3, the present study focused on the asset endowments of fish farming households and analysed the correlation of these assets with fish farming as a livelihood strategy and the overall performance of fish farming systems. A common approach is to examine the asset endowment of households guided by the livelihood pentagon to obtain a relative wealth ranking of the sample (Abo et al. 2018, Droppelmann et al. 2018, Su & Shang 2012). This contributes to a better understanding of the potentials and constraints of smallholder fish farming households. It was this approach, therefore, that mostly informed Output 1.

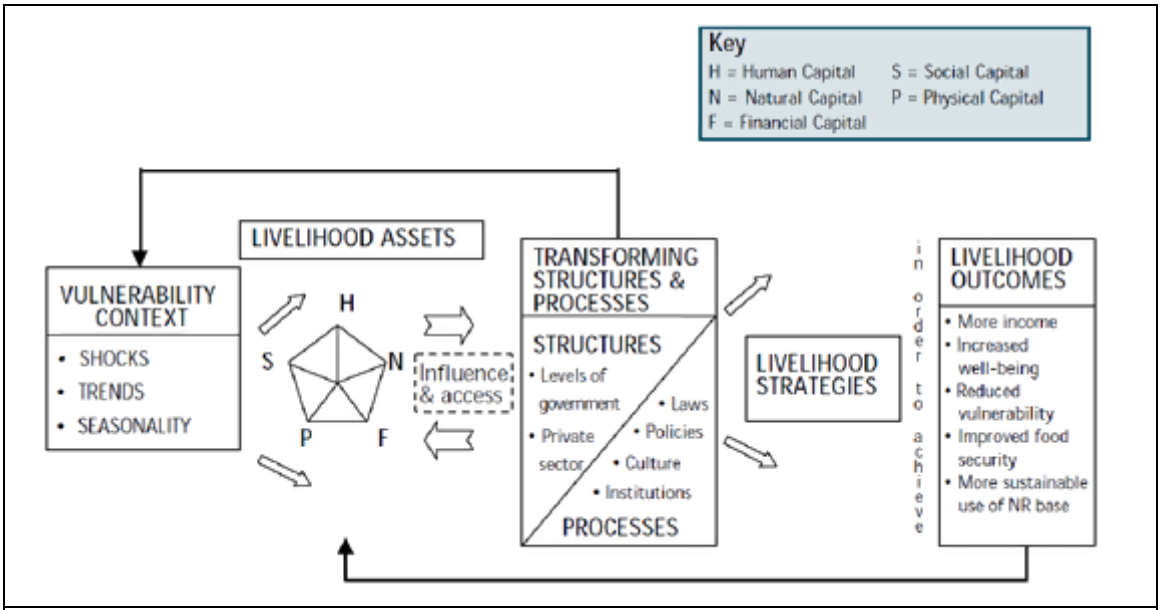

Figure 3: Sustainable livelihood framework

Source: adapted from DFID 1991: 1

3.2 Value chain approach

An understanding of the complexity of value chains is essential to improving the livelihoods of various actors in the chain. Kaplinsky and Morris (2001) define a value chain as "the full range of activities which are required to bring a product or service from conception, through the different phases of production [...] delivery to final consumers, and final disposal after use" (Kaplinsky & Morris 2001: 4). GIZ describes value chains as socioeconomic systems that are technical, economic and social systems in one (Springer-Heinze 2018).

The way in which a value chain analysis is approached depends on the end purpose, as well as the usage context of the results, including the scope, methods and technical focus. Several studies have already been conducted with a predominantly economic focus in their analyses of the entire aquaculture value chain in Zambia (see Kaminski et al. 2018, Krishnan & Peterburs 2017, Kruijssen et al. 2018a).

Springer-Heinze (2018) has developed a livelihood-value chain nexus that incorporates elements of the sustainable livelihoods approach with traditional value chain approaches, *i.e.* considering the larger upstream and downstream linkages and causalities rather than focusing on particular nodes at a given time. Since most small-scale fish farmers in rural Zambia operate outside of established commercial value chains (as described in Kaminski et al. (2018)), this study aimed

to conduct a partial value chain analysis focusing on the opportunities and constraints of small-scale fish farming households with regard to their participation in the value chain in their immediate locales. No attempt was made to conduct an analysis of the entire fish farming or tilapia value chain since this has already been undertaken by other studies (Kaminski et al. 2018, Krishnan & Peterburs 2017, Kruijssen et al. 2018a). Instead this study focused on the nexus between the value chain and the livelihood system.

Kruijssen et al. (2018a) categorises all fish producers in the value chain, as shown in Figure 4.

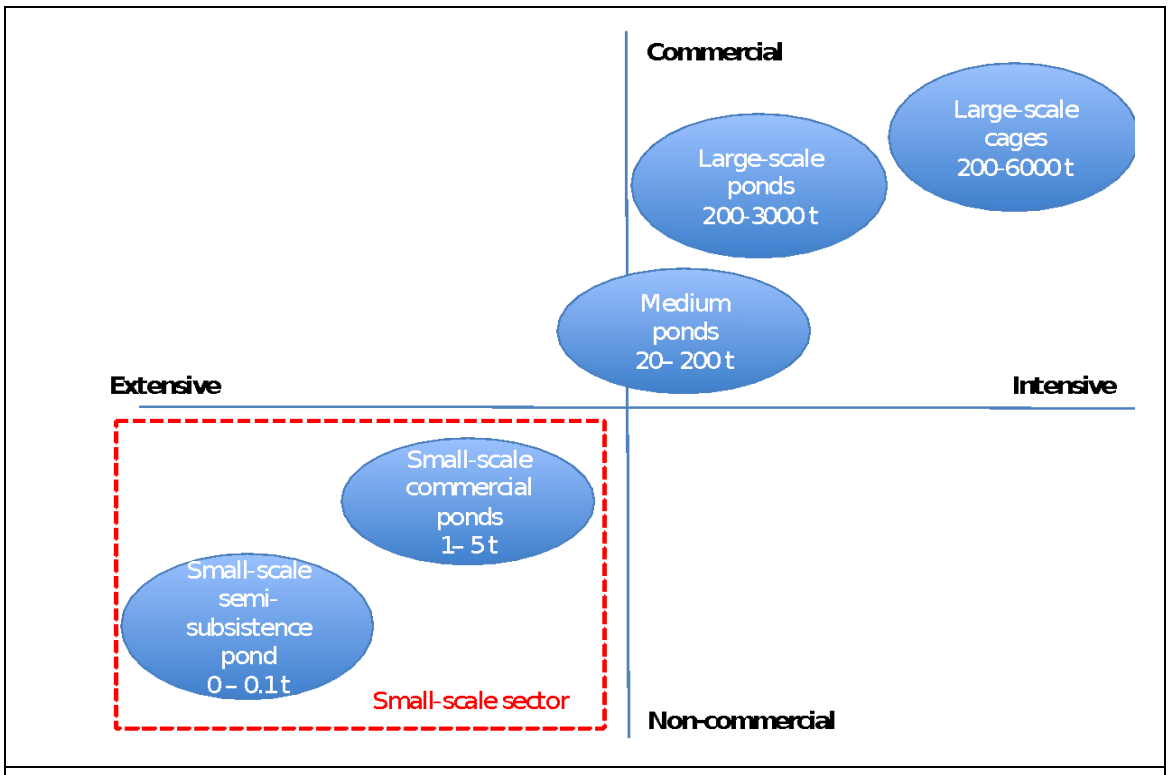

Figure 4: Typology of the aquaculture sector in Zambia

Source: adapted from Kruijssen et al. 2018a (t = tonnes of fish)

The present study looked at the first two categories. The "small-scale, semi-subsistence" pond farmers engage in aquaculture as a secondary activity, produce fish mainly for home consumption, operate extensive systems with family labour and have low total production (less than 0.5 t/year). The "smallholder commercial" pond farmers are defined as being more business-oriented, having higher levels of intensity and skills, being able to hire labour, being better integrated into the value chain and having higher production volumes (1-5 t/year). Using the value chain

approach, this study only focused on these farmers' immediate inputs and outputs, and specifically looked for differences between the northern and southern regions of Zambia. This approach, together with an in-depth analysis of the profitability of farmers (gross margin analysis), mostly informed Output 2.

3.3 Gender and youth approach

The Oxfam Guide defines "gender analysis" as exploring the relationships of women and men in society and the inequalities in those relationships. It attempts to discover how intra-household power relations are related to those at community, market and state levels, and how they enable or constrain gender equality (March et al. 1999). The argument for addressing the issue of gender in development is threefold: it strives to achieve social justice through equal rights for women and men, it is a crucial component of poverty alleviation and the realisation of greater food and nutrition security, and it contributes to economic efficiency by allocating human resources more effectively (Kruijssen et al., 2018b). It is argued that the inclusion of young people in this context fits the same desirable goals.

Despite the considerable participation of women in aquaculture, they receive fewer benefits than men due to gender disparities in the community and households, partly because their decision-making powers with regard to aquaculture remain relatively low (Weeratunge-Starkloff & Pant 2011). Compared to other agricultural sectors, gender issues have been addressed less often in key fisheries and aquaculture policies globally (GIZ 2013). The lack of quality sex-disaggregated data in aquaculture is a major constraint in developing inclusive policies (Kruissen et al. 2018b). To a large extent, this is also true in the assessment of the participation of young people in aquaculture, including the social norms, attitudes and beliefs that can constrain their participation.

Based on a different study by Kruijssen et al. (2018b) concerning how to address the issue of gender in aquaculture, the following five key issues emerge: the gender division of labour, the distribution of benefits, access to and control over assets and resources, gender and social norms, and power relations, with gender inequalities indicated in all dimensions. The same arguments can be made for the inclusion of young people. In a study on youth participation in aquaculture in Nigeria, Adelodun (2015) found that young people lack expertise or capital to engage in fish farming, and that they can often be excluded from decision-making or owning certain assets/equipment. A general lack of incentives discourages young farmers from engaging in aquaculture, which is often described as a high-risk ven-

ture. The concept of gender and youth (mostly around issues of labour division) informed Output 3 in an assessment of the intra-household dynamics that can govern who and how people engage in aquaculture.

3.4 Analytical framework

The research integrated the approaches described above into an analytical framework (see Fig. 5). While each approach informed a specific output, all three approaches were interwoven throughout the research. The primary survey unit was the fish-farming household. Households are endowed with the five main capitals differently, which provides a relative reflection of a household's capacities and wealth. Fish farming is one of many livelihood strategies employed in a household, and a primary goal was to assess whether efficiency in fish farming directly correlates with a household's "wealth" status (*i.e.* the assets with which a household is endowed). The household is made up of women, men and youths who perform various fish farming activities. This research focused primarily on fish farming as a livelihood strategy, although some comparisons and/or levels of integration with other strategies were also assessed.

Women and men's involvement in these strategies was a key focus as this research assessed the impact of certain social and economic constraints faced by farmers. This may have some influence on why and how well women and men (as well as young people) perform certain fish farming activities. While it is important to consider the livelihoods and assets of the household, a value chain approach was also adopted and opportunities and limitations assessed in the linkages to upstream or downstream nodes in the value chain. The research did not explicitly analyse all these nodes, which has been done in other studies, but specifically focused on the linkages that small-scale producing households have with these nodes. Finally, the agro-ecological (biophysical) context provides the basis for households' engagement in aquaculture and presents opportunities and barriers for how they exploit their farming systems. A focus on the seasons and how other agricultural activities interrelate with fish farming provided a systematic assessment of the farming portfolio of different households. These complex livelihood systems situated in various agro-ecological zones are also governed by various socio-economic and/or cultural factors that create social belief systems or market realities outside the household's control. This study considered these factors in order to contextualise fish farming in Zambia and provide an accurate portrayal of fish farmers' livelihoods.

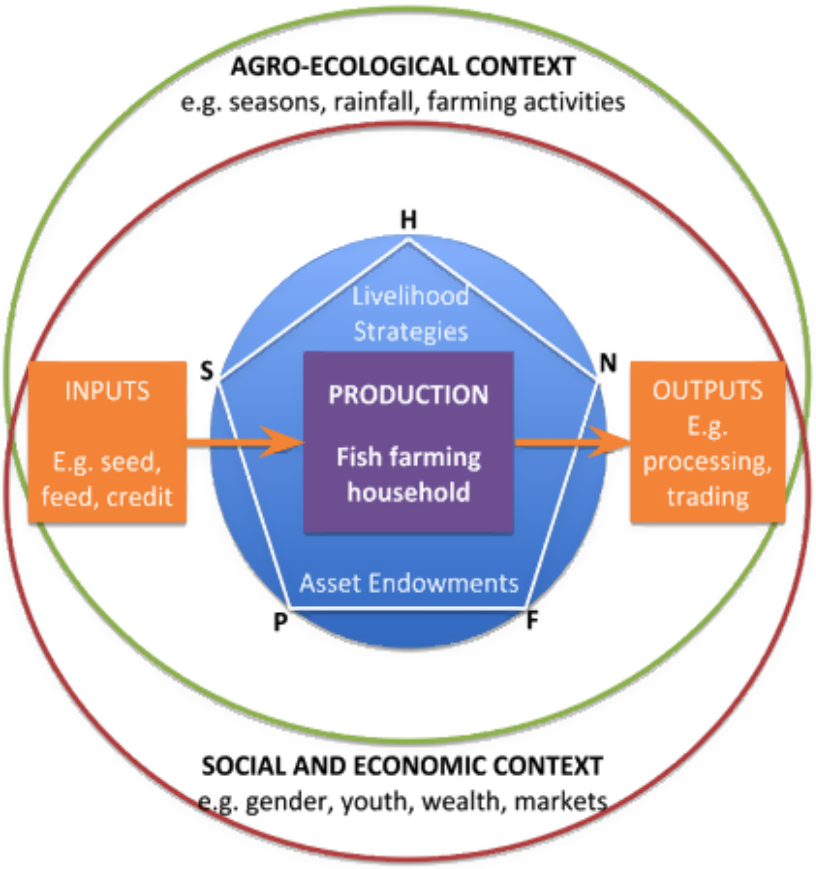

Figure 5: Analytical framework for the SLE study in Zambia

Source: own illustration

4 Methodology

This chapter introduces the sampling sites, criteria and methods used in the research, including the research design, project timeline and tools. The Theory of Change in Figure 2 above shows how the activities here contributed to the different assessments in each output.

4.1 Study sites

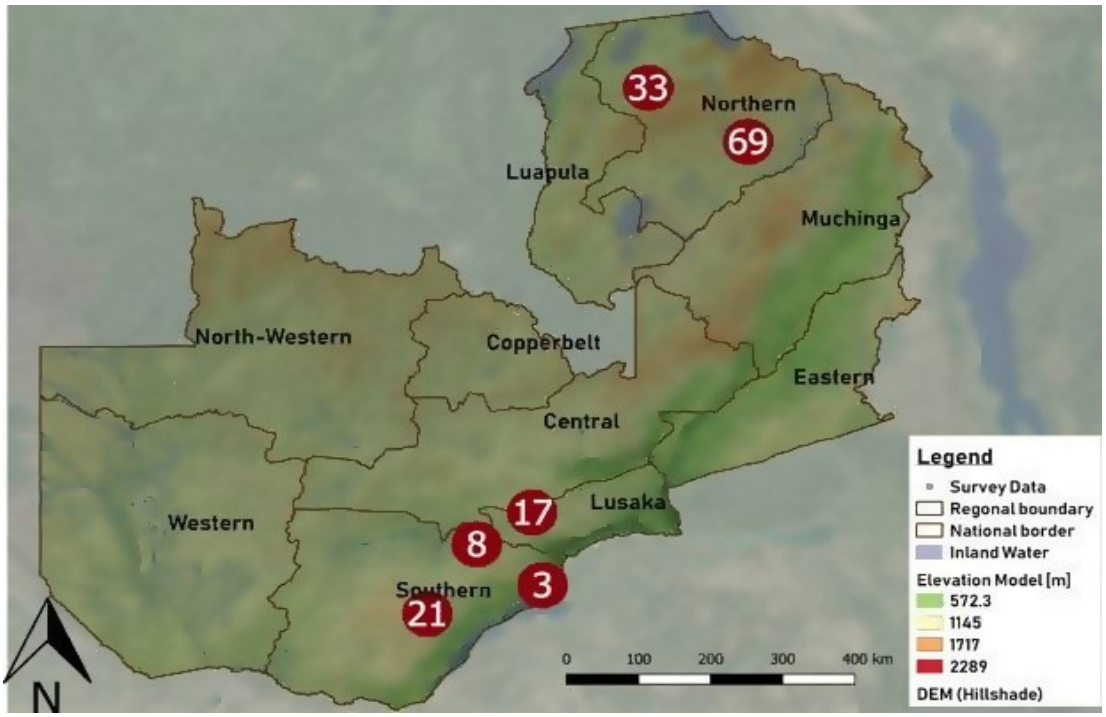

Figure 6: **Areas of observation, including the number of completed questionnaires in each region**

Numbers represent the sample of the quantitative study (n=151) in these districts: Mungwi/Kasama (n=69); Mporokoso (n=33); Kafue/Chongwe (n=17); Mazabuka (n=8); Choma (n=21) and Siavonga (n=3).

Map: D. Giese

Two comparatively different regions were selected as areas of observation to account for differences in the agro-ecological conditions for fish farming and the enabling environment, including access to inputs and markets. The team first travelled to three districts in Northern Province. These districts were chosen because the DoF reported a large number of farmers and fairly favourable conditions

for fish farming in terms of water access and soil quality. The province is home to a large number of small-scale fish farmers although there is limited access to commercial inputs. Kasama district was chosen because most farmers are located relatively near the largest town, Kasama, while Mporokoso was chosen because it is relatively far away from any large towns. Mungwi district was selected because this site was targeted under the government's above-mentioned 'aqua-park' project. The team then travelled to Southern Province and Lusaka Province in the south of the country. In interviews, key informants reported less favourable environmental conditions (*i.e.* natural water resources, terrain and soil conditions), and fewer fish farmers in the south. However, the farmers in these provinces were located much closer to the commercial sector, including large-scale producers at Lake Kariba and several commercial hatcheries and feed suppliers. The team visited Kafue and Chongwe districts in Lusaka Province, close to the capital Lusaka, where there is an emerging class of peri-urban small-scale commercial farmers. In Southern Province the team visited Mazabuka and Choma districts to assess the emerging smallholder farmers on the plateau and in (peri-) urban contexts. The team also visited Siavonga district to assess whether there any small-scale cage culture was emerging on Lake Kariba, and conducted interviews with three small-scale cage farmers.

4.2 Research methods

In order to best approximate the reality of households at a local level and to adopt triangulation strategies, this study used a mixed-methods approach to data collection, which helped reduce systematic errors and ultimately lent validity to the data (Flick 2008: 10; Blaikie 1991: 115). The study encompassed both qualitative and quantitative methods to answer the research questions and achieve the project objectives set out in Section 2.

4.2.1 Project timeline

After an initial preparation phase in Berlin, Germany (June-July 2018), the team arrived in Zambia in August to commence the research. They worked with local partners, namely WorldFish, GIZ and the DoF, to design and test the protocols and discuss the geographic sites. During this initial phase some key informant interviews were conducted to contextualise and inform the research. Data collection was divided into two phases: first, quantitative data were collected to provide a general picture of fish farmers, their asset endowments and general livelihood strategies; certain sections of the quantitative data were then analysed while in

the field to identify several farmers from each district who would serve as in-depth case studies where a qualitative inquiry would probe further into the farmers' systems, motivations, constraints and success factors. Most of the team travelled to Northern Province at the end of August 2018, while a smaller team travelled to Eastern Province to conduct the additional study (Output 4). Once in the field, District Fisheries Officers (DFOs) were trained on how to use the protocols and suitable farmers and locations were identified. After two weeks in Northern Province the team returned to Lusaka to enter, clean and analyse all the data. This process was repeated when visiting Southern and Lusaka Provinces in September. In the final weeks of October, the team analysed the data and conducted a seminar with stakeholders and interested parties to present and validate some of the preliminary results. The report was finalised upon the team's return to Berlin in November 2018, and the results were disseminated at Humboldt University in Berlin and at the GIZ Head Office in Eschborn, Germany.

4.2.2 Quantitative methods

A structured, quantitative survey was conducted to collect data on a large sample of fish farming households. The survey focused on the farmers' asset endowments, their fish farming characteristics (including linkages to inputs and output markets), and intra-household dynamics regarding the division of labour in the household. The design of the quantitative survey was influenced by key informant interviews, and carried out by research staff working in the aquaculture sector in Zambia and DoF officers. In total, 102 surveys were collected in Northern Province and 49 in the southern part of Zambia. All the farmers in the sample were terrestrial farmers with earthen ponds, except for three who had aquatic cages in Siavonga. Since the study attempted to explore all small-scale systems, the three cage farmers were included in the sample, but omitted from certain analyses in this report since cage farming constitutes an entirely different farming system that cannot be compared with pond farming. This means that most of the data were based on a total sample of 148 households. All the data were analysed with descriptive statistics using frequency distribution tables.

The Output 1 assessment looked at assets and fish farming systems and developed two scores that were then correlated. These were:

- **Asset endowment index**

A scoring system was developed to compare the asset endowments of smallholder farmers based on the literature and information supplied by key-informant interviews. Inspired by the livelihood asset pentagon described above, the five

types of capitals were assessed. A set of indicators and questions was developed for each capital. Each question would carry a certain number of points depending on the answer. For example, agricultural skills are one indicator for human capital. They are assessed partially by the number of years of farming experience. More than 20 years of farming experience give 3 points in human capital, while 11-20 years give 2 points, 5-10 years give 1 point and less than 5 years give 0 points. The higher a household scored, the better the asset endowment and the higher the ranking in terms of wealth. The ranking measured wealth not only in monetary terms but also considering other relevant livelihood assets such as social relations. The questionnaire and the scoring system can be found in Annex 2.

- **Farm Score**

The second part of the quantitative questionnaire focused on farm characteristics, with 12 criteria selected to assess the level of intensification and commercialisation of different farming systems. Based on criteria from different farming typologies found in the literature, such as types of inputs (feed and seed), use of fish, stocking densities, length of production cycles and harvesting strategy, a points system was developed for each category. The level of intensification was reflected in a farm score ranging from 5 to 56 (and then normalised to a score out of 100). For example, farmers who did not use fish feed were awarded zero points, whereas farmers using commercial feed were awarded six points. The higher the farm scores, the higher the level of intensification. For more detailed information on the scoring system, see Annex 3.

4.2.3 Qualitative methods

Based on the results of the quantitative survey, a variety of households were selected as case studies and a combination of different qualitative and participatory methods were applied. The case studies represented farmers from various sides of the spectrum based on the asset endowment and farm scores described above, *i.e.* farmers who were poor and wealthy as well as those who had extensive and intensive systems. Semi-structured interviews, according to Witzel (1982), were conducted with fish farmers. The following qualitative tools were used as part of the interview process:

- A qualitative **value chain analysis (VCA)** was used to determine the level of participation in the value chain and the associated opportunities and challenges of 22 farmers. A value chain map differentiated by geographic regions was also developed.

- A **gross margin analysis (GMA)** of the production systems of 13 farmers was conducted to further understand production performance and profitability. Gross margins calculate the profitability of an enterprise, expressed as a percentage, by deducting all variable costs from the total revenue generated (see Annex 4). Although this analysis concerns quantitative data and numbers, the data are collected through observations and qualitative interviews with farmers. It was therefore included as a component of the qualitative inquiry since this approach provided crucial insight into the productivity of selected fish farmers, which the quantitative survey was unable to obtain through simple recall methods.
- **Seasonal calendars** were compiled with 11 farmers to better understand the seasonal issues of fish farming and other agricultural activities to provide an account of how household labour is used on the farm as a whole and how fish farming fits into households' wider agricultural plans.
- Three **gender-differentiated focus group discussions** (FGD) probed women and men's perceptions of the division of labour around aquaculture-related activities (*e.g.* stocking, feeding, harvesting *etc*.). Gender-separated focus groups were intended to counterbalance the gender power dynamics and create an open space for women and men to discuss how aquaculture is implemented as a household activity.

Qualitative datasets were based on hand-written field notes and transcribed through a translator. The data were later coded and analysed using qualitative content analysis according to Mayring (1991) using the qualitative coding software Atlas.ti. All datasets were sex-disaggregated in order to be in line with basic standards of gender analysis (Doss & Kieran 2014).

Table 1: Numbers of farmers interviewed disaggregated by gender

Method	Tool	Women	Men	Total
Quantitative	Questionnaire	39	112	151
Qualitative	VCA	6	16	22
	GMA	3	10	13
	Seasonal calendar	4	7	11
	FGD	3 groups (2 women-only, 1 men-only)		

Source: own data

4.2.4 Sampling

Following the typology developed by Kruijssen et al. (2018a), this study focused on fish farmers who fall into the categories of 'small-scale semi-subsistence farmer' and 'small-scale commercial farmer' as selection criteria. A purposive sampling method was applied where members of a particular group are subjectively targeted based on certain characteristic or traits. This method was beneficial in this context because the sample size of relevant households is small and because there is little information on small-scale fish farmers' locations or their status, *i.e.* currently producing or having abandoned production. This type of sampling allowed the inclusion of a heterogeneous range of farmers based on different criteria such as gender, age, wealth, location and production. Informal social networks were relied on to identify specific respondents who were otherwise difficult to locate (see Trochim & Donelly 2006: 51-58). Different groups of farmers were therefore targeted to draw on a range of factors that characterise the sector. The aim was to find male and female farmers, rural and peri-urban farmers, as well as farmers with different levels of wealth and farming systems with different levels of intensity and production. This approach was applied for both the quantitative and qualitative samples, although the latter were based on initial analyses from the former.

DoF extension officers were the main sources of information for locating and interviewing farmers. The officers were the primary link between the DoF and smallholder fish farmers. Since official registers with relevant information are not always updated or available, extension officers facilitated the team's entry and access to smallholder farmers.

Image 7-8: Harvesting fish from a concrete pond [left], discussing a seasonal calendar with farmers [right]

Photos: D. Giese

5 Results

5.1 Assets, farm characteristics and livelihoods (Output 1)

5.1.1 Assets and farm characteristics

5.1.1.1 Production classes

Of the 151 households who participated in the survey, only 133 households used land-based systems and were able to provide information on their annual fish production (*i.e.* how much fish had been harvested from the ponds in the past twelve months). The missing 18 respondents comprised three cage farmers and 15 pond farmers who were unable to or did not produce any fish in the previous 12 months. The fish farming households (n=133) who were able to provide production data from ponds had harvested on average 161 kg (SD= 323) of fish in the last 12 months. The amounts of fish harvested ranged from a minimum value of 5 kg up to a maximum of 2,000 kg per farmer. The farmers were grouped into three different production classes. Most of the respondents (69.2 %) had produced less than 100 kg in the previous 12 months and were categorised as "low production". About a quarter of the sample (24 %) had harvested between 100-500 kg fish in the previous 12 months and were termed "medium production". Only 9 farmers (6.8 %) in the sample had produced more than 500 kg in the last 12 months. These were classified as "high production" (see Table 2).

Table 2: Production classes of small-scale fish farmers

Production class	Number of households	Share of sample (%)
<100 kg	92	69.17
100-500 kg	32	24.06
>500 kg	9	6.77

Source: own data

5.1.1.2 Area of production

Productivity was difficult to calculate in these contexts given that many farmers do not keep records and/or do not know how many fish are in their ponds or how many fish they consume, as well as not keeping records of how much feed

they apply. Therefore, the results on productivity below should be considered with care. Productivity is shown as mean tonnes per hectare (t/ha) of the three production classes (see Fig. 7). The low producers had harvested an average of 3.22 t/ha (SD=7.89) in the previous 12 months, while the medium producers had harvested an average of 5.02 t/ha (SD=4.73), and the high producers an average of 12.98 t/ha (SD=17.40) in the previous 12 months. The high standard deviation shows the variation within the different classes (see Fig. 7).

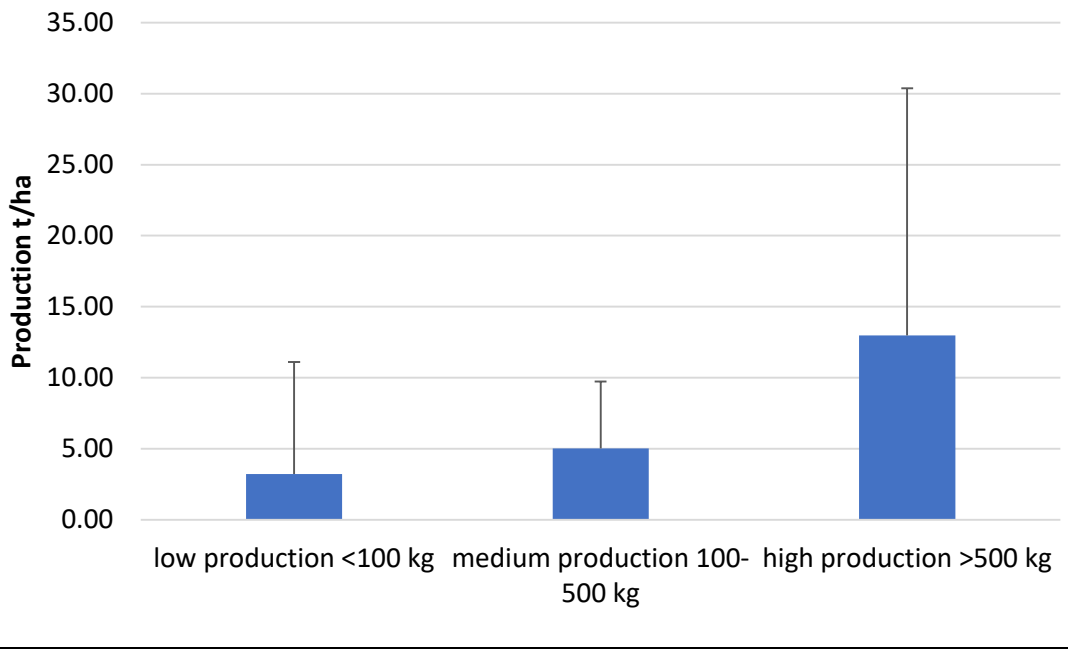

Figure 7: Productivity (t/ha) per production class

Source: own illustration

The water surface area of the three production classes is shown in Table 3. The means, standard deviation, and minimum and maximum values show the high variation within the groups. The highest producers also operated on average the largest pond areas. The largest total surface area of one farmer (28,128 m²) was found in this group, which was far above the average and biased the mean.

Table 3: Water surface areas (m²)			
	Mean m² (=SD)	**Minimum value (m²)**	**Maximum value (m²)**
Low production	735 (=1120)	12	7,600
Medium production	1130 (=1829)	55	10,000
High production	5752 (=9031)	300	28,128
Source: own data			

5.1.1.3 Farm characteristics and farm score

An investigation of the characteristics of the aquaculture system operated by the households (n=133) revealed a variety of inputs, systems and management strategies applied by small-scale fish farmers. All small-scale fish farmers from this sample used land-based production systems such as earthen ponds (83 %), earthen ponds with a plastic lining (6 %) and concrete ponds (11 %). Farmers had three ponds on average (SD=3.07), although the numbers ranged from 1 to 24 ponds. The total size of all ponds ranged from 12 m² to 28,128 m² with an average of 1,177 m² (SD=2,881.7).

Table 4 displays the differences in the farm system of the three production classes. The low-producing farmers mainly used a low-cost input system with plant-based supplementary feed (87 % of farmers), irregular buying and restocking of new fingerlings (75 %), and low stocking densities (49 %). Most of the farmers in the low-production class applied a partial harvest system[4] (60 %) and did not keep records on their aquaculture activities (70 %). The average farm score of low-producing farms was 41.9 (SD=12.45).

The medium production class showed a diverse picture in their farm characteristics, with slight majorities using medium and high stocking densities (55 %), buying fingerlings every cycle (63 %), keeping records (56 %) and feeding daily (58 %). There was a wide variation in the farm characteristics of the medium production class, which was also reflected by the high standard deviation (20.21) of the average farm score (55.4).

Fish farmers who produced more than 500 kg of fish per year all used commercial feed, daily feeding regimes, record keeping, buying fingerlings every cycle and producing mostly for selling. The majority (78 %) of the high-producing farmers

[4] This system involves farmers harvesting fish throughout the cycle instead of waiting until the end of the cycle.

used sex-reversed fingerlings, and most of them (67 %) had a six to seven-month production cycle. The measured criteria for the high-producing farmers resulted in a farm score of 83.01 (SD=10.78).

Table 4: Farm score results as a percentage of farmers from each class

	Production classes (%)		
Criteria	<100 kg (n=92)	100-500 kg (n=32)	>500 kg (n=9)
Source of seed			
Wild, recycled, fellow farmers	57	35	0
Government hatchery	39	48	44
Improved seed (privat hatchery)	4	16	56
Feed			
No feed	1	3	0
Vegetables	57	22	0
Maize bran	30	28	0
Homemade feed	2	3	0
Commercial	10	44	100
Frequency of feeding			
Not daily	51	42	0
Daily	49	58	100
Fertiliser			
No fertiliser	11	6	0
Manure/compost	86	88	78
Chemical	3	6	22
Use of fish			
Home consumption	34	9	0
Selling	63	84	100
Other	3	6	0
Type of fingerlings			
Do not know	32	19	0
No sex-reversed	54	56	22
Sex-reversed	14	25	78
Stocking density			
Do not know	38	16	0
Low (1-3 fish/m²)	49	29	33
Medium (3.5-5 fish/m²)	10	39	22
High (>5 fish/m²)	2	16	44
Record keeping			
No	70	44	0
Yes	30	56	100
Buy fingerlings every cycle			

No	75	37	0
Yes	25	63	100
Equipment			
Nothing	23	16	0
Basic	44	34	11
Medium	27	25	0
Advanced	5	25	89
Harvest strategy			
Partial	60	45	22
Length not known (+7 months)	23	19	11
6-7 month cycle	16	35	67
Farm score	39.27 (SD=13.16)	53.18 (SD=20.22)	82.51 (SD=11.90)
Source: own data			

5.1.2 Asset endowment of fish farmer households

Human capital

As relevant indicators of human capital, the agricultural skills, education and available labour force within households were measured. Differences in the score in human capital were mainly determined by the years of farming experience the head of the household had. Some people had fewer than five years of experience (15 %) while others had 5-10 years (26 %) or 11-20 years (28 %), although most had more than 20 years (31 %). The longer the experience, the more points were awarded. The answers to the remaining questions were less diverse. Most households had not attended more than two formal training courses on farming practices in the previous twelve months (75 %). With regard to literacy and education, most households stated that either the majority (47 %) or all adult household members (50 %) could read and write. Around 43 % of households had at least one member of the household who had finished secondary school, while 30 % of households had at least one member who had had a tertiary education. Labour force availability was measured by a dependency ratio in terms of the number of non-working household members to working household members. Work is understood as any contribution to household activities including domestic chores. Two thirds (66 %) had a dependency ratio of less than 0.5.

Social capital

Social capital was mainly determined by the relationship to the village authorities and extension officers. Only around 14 % of households spoke to extension officers once a week, while the majority of households (35 %) spoke to extension

officers once a month. The remaining 37 % of households spoke with an officer less than once a month, while 14 % said that they never spoke to such officers. The relationship with the extension officers was seen as 'good' (78 %) or 'non-existent' (22 %). Information on farming was usually accessed directly through the extension officer (77 %). Regularity of communication with the village authority differed with 'less than once a month' (23 %), 'once a month' (29 %), 'every week' (19 %) and 'every day' (24 %). Most households participated in farmer organizations (82 %) and other social organizations, such as church groups (89 %).

Financial capital

There were large differences in the households' financial capital. Seven classes were provided referring to annual income from (a) farming activities, (b) non-farming activities, and (c) annual investments in the farm (*i.e.* in the previous 12 months). The households were asked into which of the classes they fell. Table 5 shows the household distribution among the seven categories. With regard to annual income through farming activities 46 % said they generated less than 255 USD, 48 % made between 255 and 2,100 USD, and only 6 % earned more than 2,100 USD. In terms of annual non-farming income, 66 % generated less than 255 USD, 21 % between 255 and 2,100 USD, while 13 % earned more than 4,200 USD from non-farming activities. In terms of financial investments in their farms, about two thirds (61 %) of the households invested less than 255 USD, 29 % between 225 and 2,100 USD and 10 % more than 2,100 USD.

Table 5: Income (USD) per (non-) farming activities (% of respondents)

Amount	Income through farming activities	Income through non-farming activities	Investments in the farm
< 85 USD	16 %	45 %	32 %
85 -255 USD	30 %	21 %	30 %
255 – 420 USD	14 %	5 %	14 %
420 – 840 USD	22 %	8 %	7 %
840 – 2100 USD	12 %	8 %	8 %
2100 – 4200 USD	4 %	2 %	5 %
> 4200 USD	2 %	11 %	5 %

Source: own data

Financial capital was further assessed through access to credit, availability of remittances and hired labour. With regard to access to credit, 30 % of farmers stated that they had no access to any external capital, while 40 % were capable of

accessing loans in informal ways and through saving groups, and 30 % said they had access to a formal bank loan. Two thirds (65 %) did not receive any remittances. About one quarter (24 %) were unable to afford hired labour, while 58 % hired only seasonal labour and 18 % hired either permanent labour or both seasonal and permanent labour.

Natural capital

Natural capital was mainly determined by the area of land owned, the form of land ownership, and the number and type of livestock owned by the households. About half (47 %) of all households owned less than 5 ha, while about a quarter (27 %) owned between 5 and 10 ha, and a further quarter (26 %) owned more than 10 ha. Regarding the form of ownership, the majority of households (78 %) did not possess a formal land title but held a form of customary land tenure. Nearly half of the households (48 %) used less than half of their land, while the rest used more than half (38 %) or all of their land for agricultural purposes (14 %). Water was available all year around on 89 % of the farms. Natural capital in terms of livestock was measured by the tropical livestock unit (TLU) (see Jahnke (1982)) where households usually scored highly if they had cattle or pigs, or if they had a large number of chickens, depending on the number. The majority of households (81 %) scored fewer than 5 points on the TLU, which would be equal to seven cattle, 24 pigs or 490 chickens. Half of the households (50 %) scored fewer than 0.5 points on the TLU, which equates to less than one cow, 2.5 pigs or 50 chickens.

Physical capital

In terms of housing conditions, houses were made of brick and mud (53 %) or brick and cement (47 %). Rooftops were either made with iron sheets (75 %) or straw (25 %). Half of the households (50 %) had at least one bedroom per two household members, while the other half had more than two household members per bedroom. About a quarter (26 %) had no access to electricity, while 42 % relied on solar energy for some basic appliances, and about one third (32 %) had access to electricity through the state-owned power company. Water for domestic and farm purposes was accessed from unprotected natural sources (44 %), protected natural water sources (15 %), improved water sources shared with others (14 %) or private water sources (27 %). Only one in eight households possessed advanced agricultural tools, such as machines and fuel-driven devices, while 53 % possessed medium and advanced tools such as sprayers, and 35 % possessed only basic digging tools. With regards to the means of transportation, more than half of the sample possessed a bicycle (59 %), while one in four households (26 %) owned a car.

Total asset score

The scores from the five capitals were normalised and combined into a total asset score between 0 and 100 points. Each of the five capitals contributed an equal share of a maximum 20 points to the total score so that a low score in one of the capitals could be compensated by a higher score in one of the other capitals. The highest total score of all households was 87.0 and the lowest was 22.2, with a median of 52.2 and a mean of 53.5.

5.1.3 Asset endowment of different production classes

To investigate how fish production and livelihood assets are interrelated, an analysis was conducted of how "low", "medium" and "high" producers, according to the production classes, were equipped with different assets according to the five capitals of the livelihood asset pentagon. This gives an idea of which capitals may be more prevalent and/or important to the success of a fish producer (measured as total production).

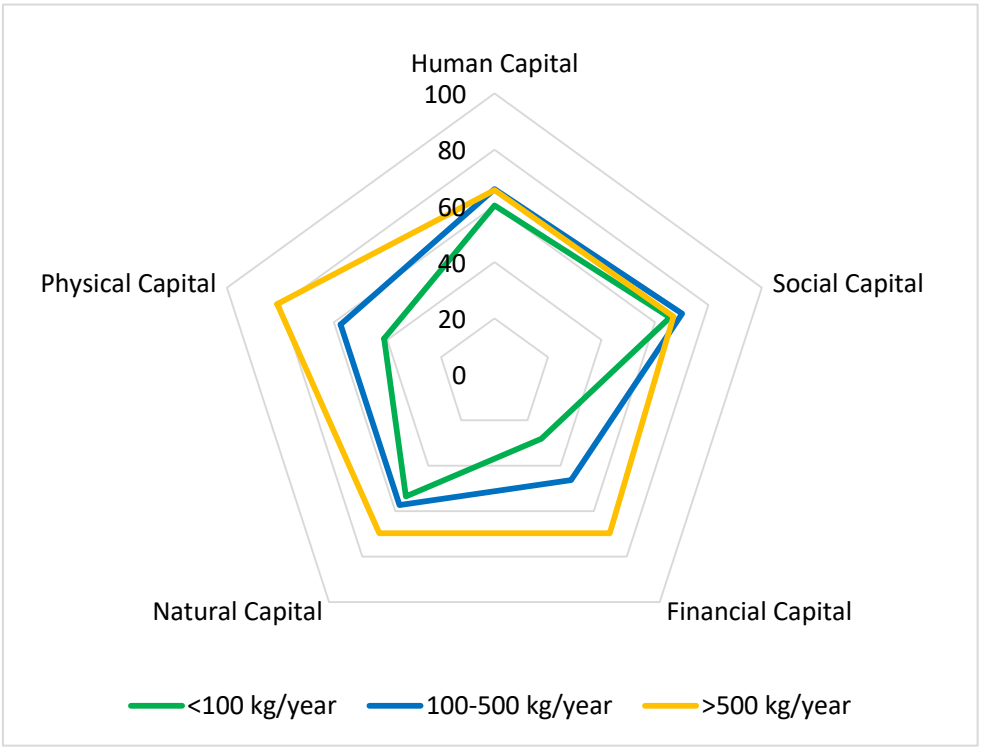

Figure 8: Asset endowment of different production classes

Source: own illustration

Figure 8 shows that the higher-producing households were better equipped with livelihood assets in general. The difference in asset endowments between the production classes differed drastically when looking at individual capitals. The greatest differences were found in terms of financial and physical capital, while the differences in terms of natural capital were moderate. There were no real differences for social or human capital. This may indicate that endowment with social and human capital does not have a strong influence on how much fish is produced by the household, while financial and physical assets seem to support fish farm systems with higher production.

5.1.4 Farm intensity, wealth and production

Having investigated how production was correlated with both household wealth and farm characteristics, the correlation between all three aspects was examined. To better understand the interlinkages between all three variables, the data of farmers' asset scores, farm scores and production (kg) are displayed in a scatterplot (see Fig. 9). The figure reveals a correlation between wealth and farm intensity (asset score and farm score) as better-off households generally operated more intense farms. However, this did not always result in higher production. Figure 9 suggests that only those farmers with a farm score above 66 produced more than 500 kg of fish per year. In terms of wealth and production, fish farmers from the high-production class also had a high asset score above 50 points. The only exception was one fish farmer from the north who produced more than 500 kg with a relatively low asset score of 44. Medium producers seemed to be mixed with high asset and farm scores as well as with low asset and farm scores, while most low producers scored low in asset and farm scores. While there were also low-producing households with relatively high asset and farm scores, there were no households in the 'high' production category with a low asset and farm score.

Combining these three aspects suggests that asset endowment and level of intensity have a positive impact on a household's total fish production.

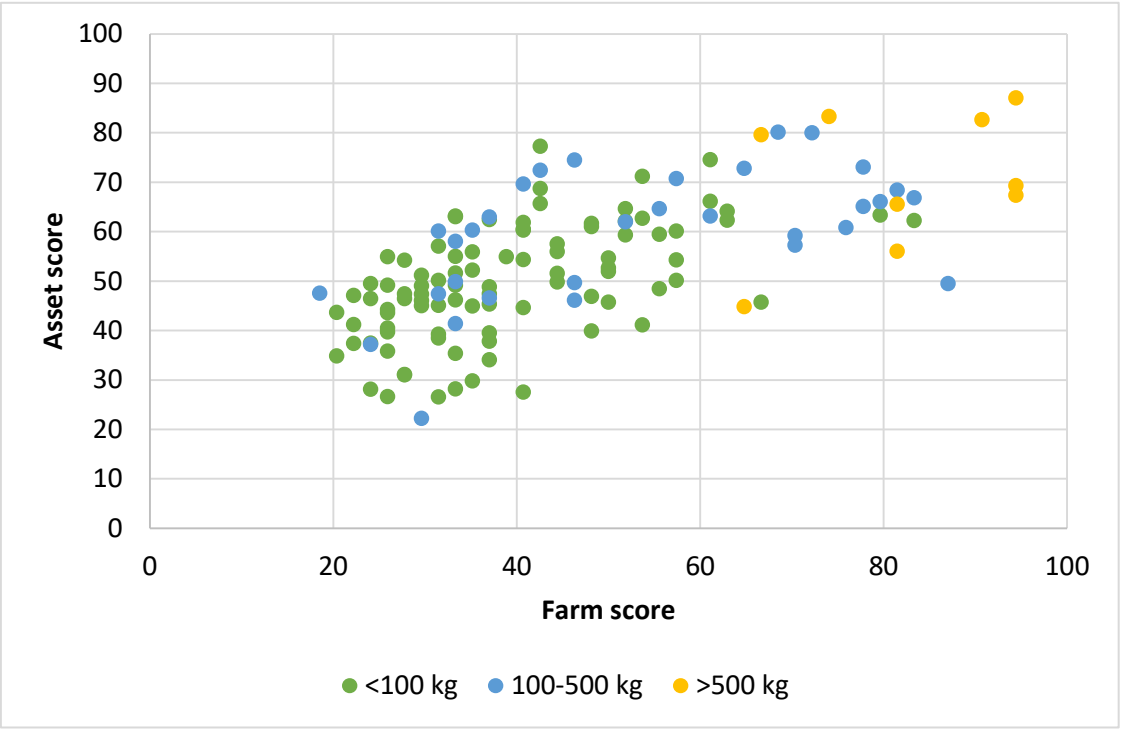

Figure 9: Household wealth and farm intensity

Source: own illustration

5.1.5 Regional differences

The following section contains a comparison of characteristics of small-scale fish farming households in northern and southern Zambia. The sample was disaggregated based on the location of farmers, and the farmers from the two regions compared in terms of wealth (based on the asset scores), farm intensity and production, as well as some specific differences in the production system characteristics.

5.1.5.1 Regional differences in asset endowment, farm characteristics and production

A comparison of the average asset endowments of fish farming households in the northern and the southern sample revealed that there were no differences in average endowments with natural, human or social capital. The southern sample was better equipped in financial capital than the northern sample (see Fig. 10). Focusing on the asset endowments of the five highest scoring households from the south and from the north revealed further interesting insights. The average total score of those high-scoring households was similar (south: 80, north: 79), but the households in the south scored higher in natural capital (south: 87, north: 71), financial capital (south: 85, north: 76) and physical capital (south: 90, north: 85),

while the households from the north compensated for these lower scores with higher scores in social capital (south 71, north: 85) and human capital (south 63; north 78).

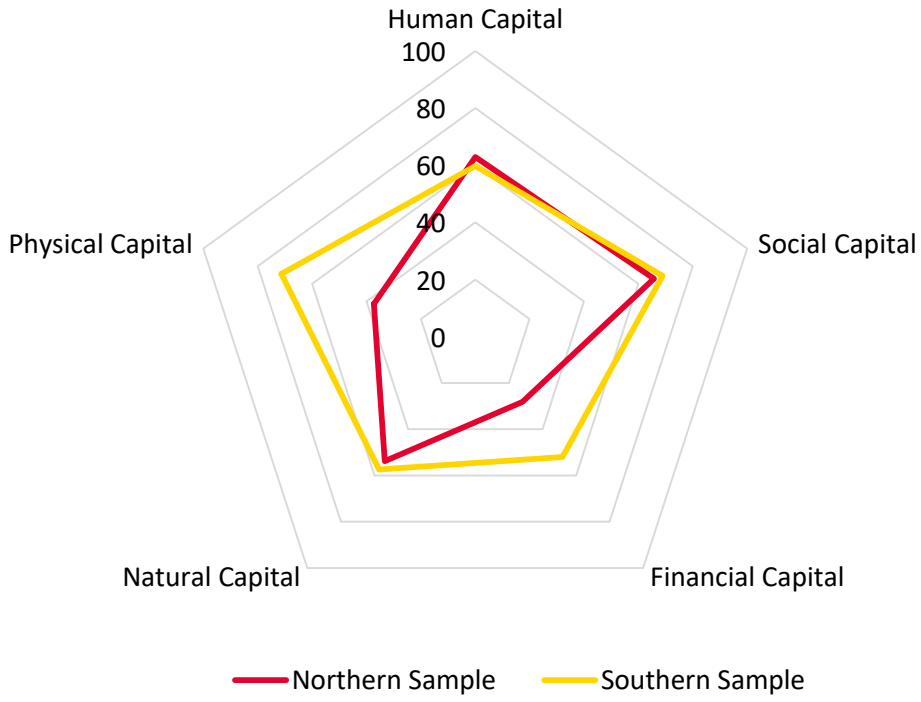

Figure 10: Asset endowment and location

Source: own illustration

As illustrated in Figure 11, fish farming households in southern Zambia tended to have more intense production systems and higher asset endowments compared to those in the north. The average asset score in the north was 49.4 (SD= 12.7) and the average farm score was 38.7 (SD= 13.4). In the southern region, fish farming households had an average asset score of 62.7 (SD= 10.1) and an average farm score of 60.8 (SD=20.6).

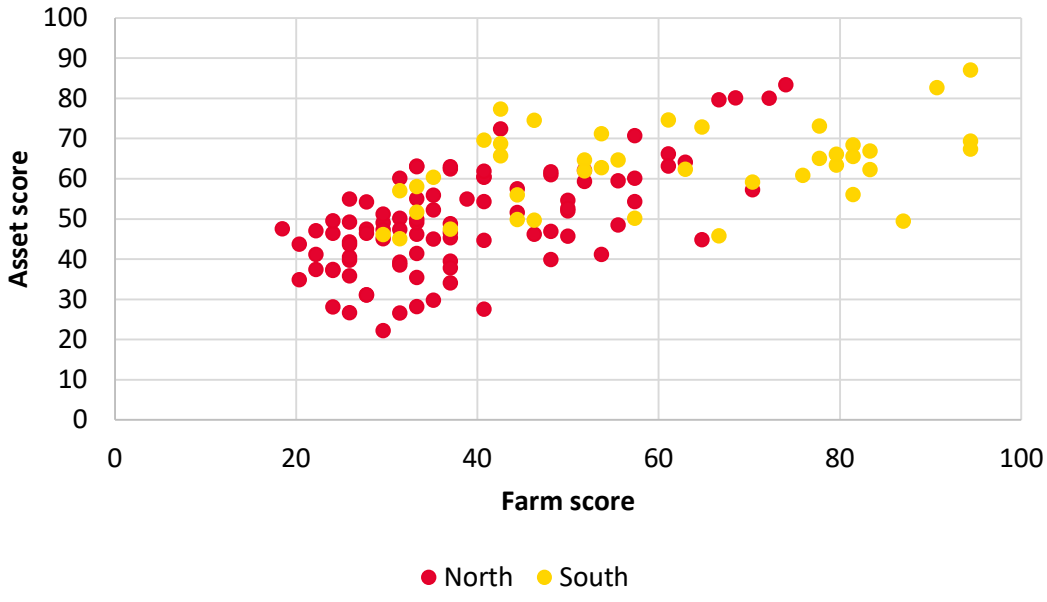

Figure 11: Household wealth and farm intensity by location

Source: own illustration

A closer look at farm characteristics revealed differences in the operation of aquaculture systems between the northern and southern samples (Fig. 12). The data show that more fish farmers in southern Zambia used commercial feed (56 %) and sex-reversed fingerlings (41 %) compared to fish farmers in the north (10 % and 12 % respectively). Another major difference was that some fish farmers in southern Zambia (27 %) applied high stocking densities (>5 fish/m²), whereas no farmers in the north did so. Other distinctions were that more fish farming households from the south used advanced equipment and concrete ponds, and purchased fingerlings every cycle.

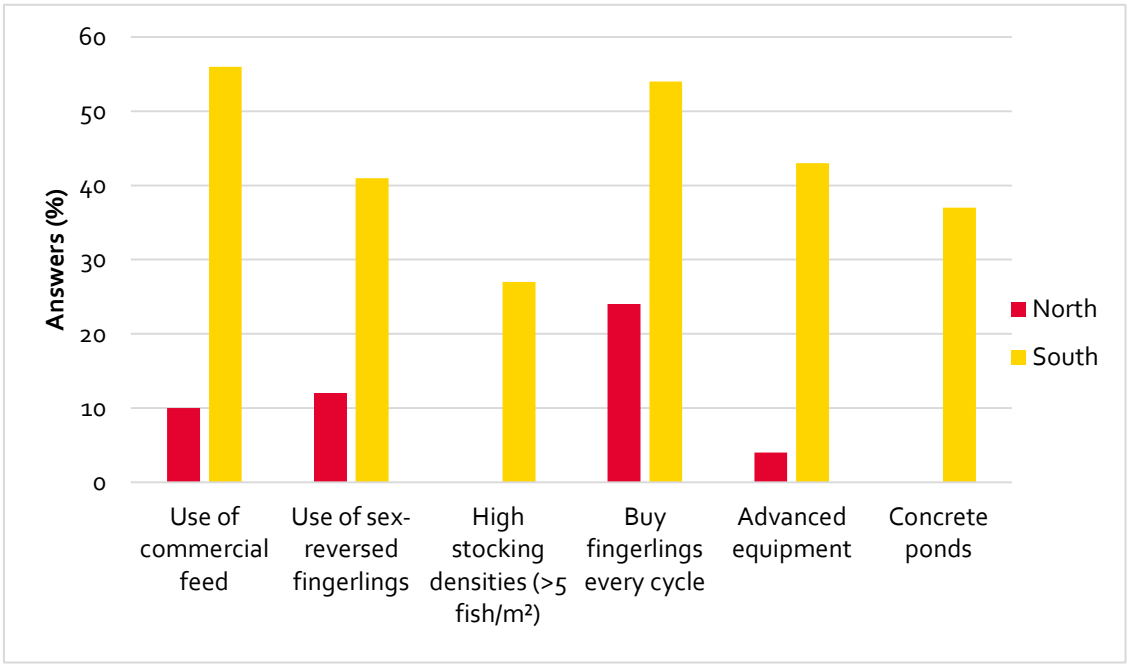

Figure 12: Farm characteristics in northern and southern Zambia

Source: own illustration

Regarding the production of fish in the previous 12 months, there was a lower overall production of fish per farmer in the north (mean= 92 kg; SD= 156), compared to higher production in southern Zambia (mean= 317 kg; SD= 503). There was a wider variation in fish production capacity in southern Zambia, with 46 % of farmers classified in the 'low' production class, 39 % in the 'medium' production class and 15 % in the 'high' production class. In the north the majority of fish farmers (79 %) were in the 'low' production class, 18 % in the 'medium' production class and only 3 % produced more than 500 kg.

5.1.6 The role of fish farming in livelihoods

5.1.6.1 Contribution to incomes

Most of the respondents (78 %) perceived fish farming to be an activity intended for income generation rather than one that primarily served other needs such as home consumption (22 %). This perception was more pronounced in the south, where 91 % of the farmers stated that fish farming was a key business activity, while 90 % of farmers in the north stated that it was one sideline activity among many other livelihood strategies. Overall, the majority of fish farmers (57 %) stated that their household income had increased since starting fish farming.

Livelihood diversification was evident when farmers were asked to rank their five main income sources in the previous twelve months. The most frequently mentioned main source of income for all households involved in fish farming was the sale of staple crops (38 %), followed by non-farming income activities such as formal employment or businesses (24 %). Only 8 % of the interviewees named aquaculture as their first source of income, but a considerable number of households mentioned it as a second (20 %) or third (36 %) income source.

When grouping farmers according to the three production classes, it was clear that high-producing households (n=9) relied on non-farming income (5 out of 9 households) or aquaculture (2 out of 9 households) with the remainder relying on livestock as their first source of income. The most important income sources for low-producing households were staple crops (47 % of households) followed by vegetables (19 %) and non-farming income activities (18 %) (see Fig. 13).

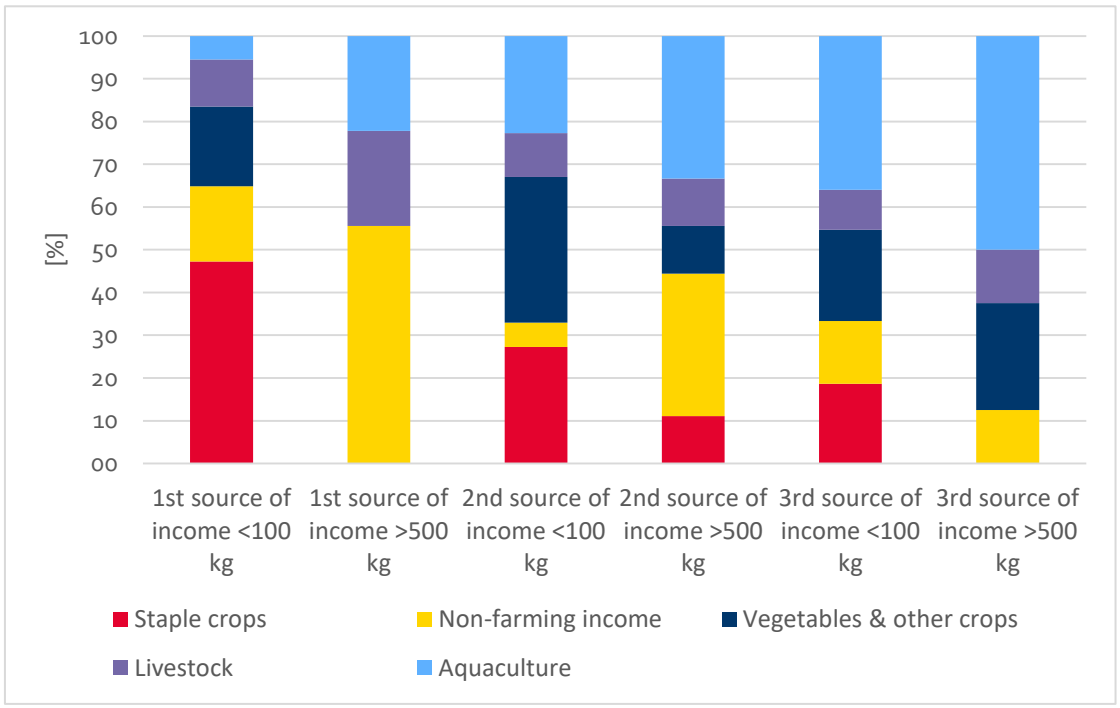

Figure 13: Income sources per production class

Source: own illustration

5.1.6.2 Contribution to household food consumption

Households were asked to rank the five most important food items sourced from their own farm for household consumption. Maize was ranked as the main crop grown on the farmers' own farm that contributed to food consumption (79 % of households). 'Vegetables' and 'other staple crops' such as cassava and millet were mentioned most frequently as important secondary food sources (37 % and 22 % respectively). Meat and fish from the farmers' own production played a role in consumption and were mostly mentioned as the third or fourth priority. While fish was mentioned as the main source of food from the farmers' own production for only 6 % of households, it was ranked by more than half of the sample as a third (21 %) or fourth (39 %) source (see Fig. 14), thus showing its relevance to dietary diversity for many farmers.

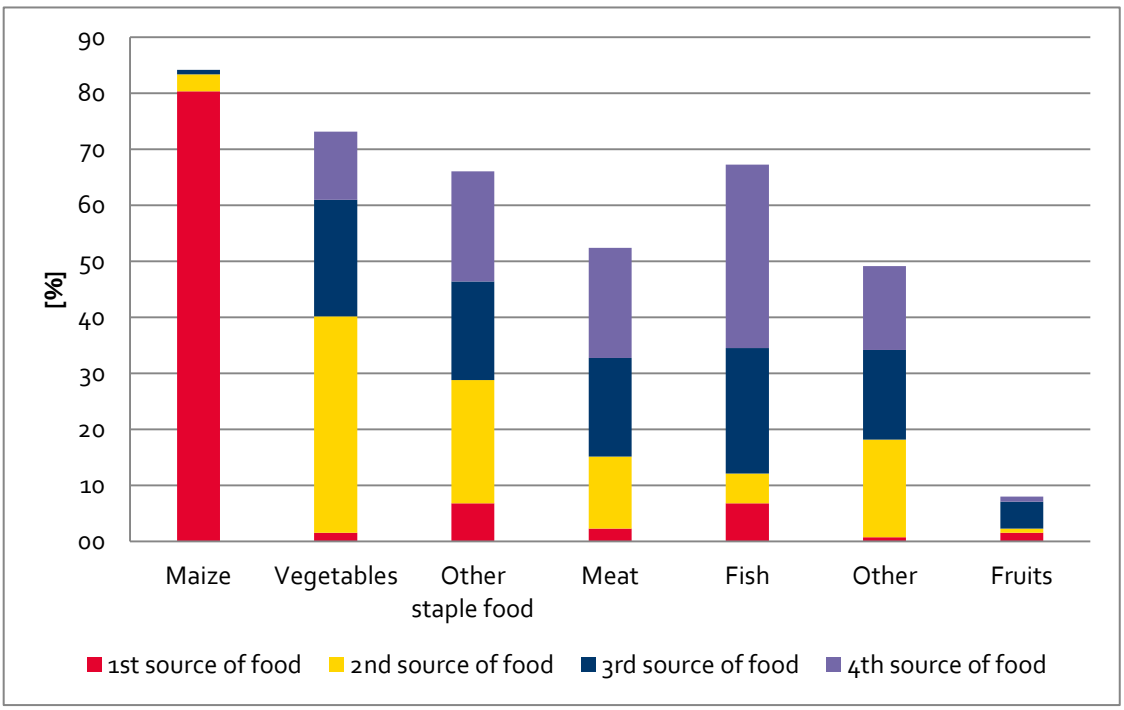

Figure 14: Contribution of farm products to household consumption

Source: own illustration

Farmers were asked how often they consumed fish from their own ponds. Most farmers (75 %) consumed fish from their ponds at least once a month and 13 % consumed fish weekly. Only 2 % of farmers stated that they never ate fish from their ponds (see Fig. 15).

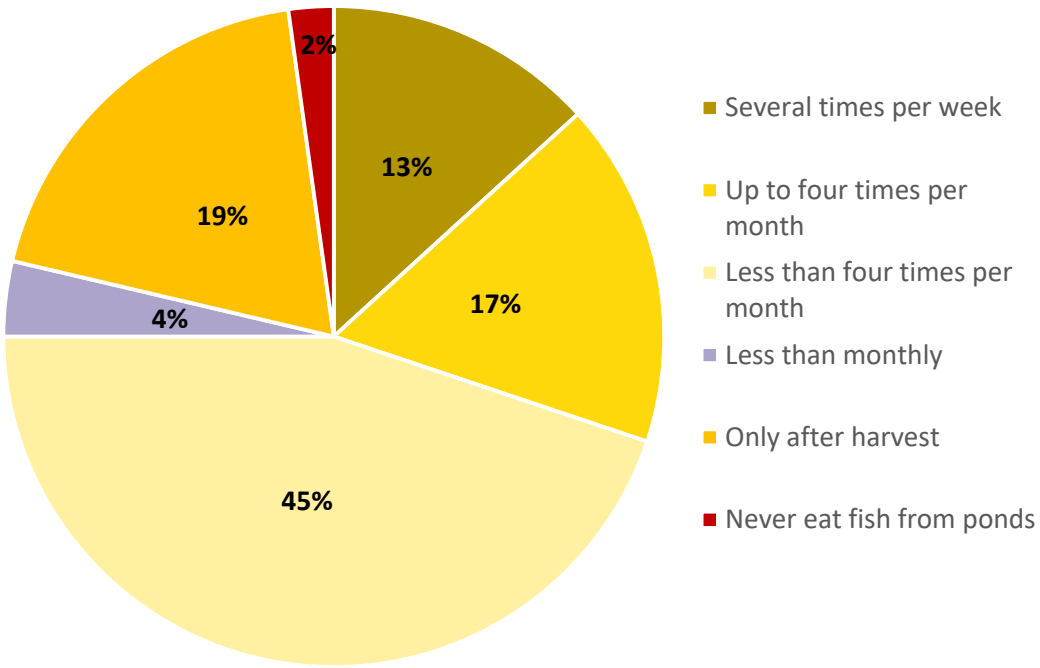

Figure 15: Households' frequency of consuming fish from own pond

Source: own illustration

5.1.6.3 Aquaculture as a livelihood strategy

Seasonal calendars were a helpful tool for conceptualising fish farming as one activity in a portfolio of many other livelihood strategies. The visualisation provided a better understanding of the seasonality of farming activities. Eleven case studies highlighted diverse livelihood portfolios and provided the influencing factors on the shape and timing of the case-specific fish farming cycles. In accordance with the quantitative results, no evident period could be determined as a "fish-farming season". In other words, there were no months during which farmers predominantly stocked their ponds or harvested. Moreover, most farmers did not follow a specific yearly regime, highlighted by the fact that more than half of the farmers stated that the time of stocking (56 %) and harvest (55 %) varied from year to year. As seen above, almost all the farmers also received most of their income and source of food from other agricultural or non-agricultural activities.

The seasonal calendars showed that in general almost all the farmers juggled several farming activities. These activities were dependent on rainfall as well as the types of crops that were grown. The calendars revealed the gendered division of labour throughout the year, with women and men performing different activities. This topic is explored in more detail in the results for Output 3 below. The calendars further showed how various farming activities take place at the same time and that these activities often coincided and were interdependent, *e.g.* manure from livestock can be added to ponds while water from ponds is used to irrigate vegetable gardens. The main difference between farmers in the north and the south was that in the latter, livestock seemed to be more prevalent. According to key informants this was due to the predominantly Tonga ethnic group that dominates here, which is commonly regarded as a livestock-rearing culture. This was in contrast to mostly Bemba farmers in the north who are largely crop and vegetable farmers. This shows that ethnicity is likely to play a large role in determining the livelihood strategies of farmers, although this was not actively researched in this study. It is also likely to be a result of agro-ecological conditions since there are more water sources and higher rainfall in the north, while conditions in the south are more arid.

While a diverse sample of 11 seasonal calendars was collected from male and female farmers in Northern, Southern and Lusaka Provinces, we present one case of a female fish farmer that provides some insight into the yearly livelihood (farming) activities of a typical low-producing fish farmer. As is the case for most farmers, aquaculture constituted only a small part of her livelihood.

The seasonal calendar from Choma district in Southern Province showed a diversity of cropping activities that were relevant for household income and consumption (see Fig. 16). This female farmer's main produce, as with many other farming households, was maize. She also cultivated sweet potato, groundnuts, beans and vegetables. In the last year (October 2017 to September 2018) her busiest months were December to May. Typical for a Tonga household in the south, she reared cattle as her most important livestock, but also kept poultry. As illustrated in the "integration" column, she used much of her own farm produce for fish farming, such as manure for fertilisation and vegetable leaves for fish feed. Pond water could occasionally be used for watering vegetables or as a source of drinking water for livestock.

With regard to her fish farming activities, the top half of the seasonal calendar (Fig. 16) shows a fish production cycle that is common for many rural small-scale farmers in that specific area. It was disrupted by the dry season between October

and November. She worked continuously on fish farming activities after stocking in January. She also stated that fertilisation required particular attention as the quality of soil was not conducive to maintaining the desired nutrient level in the water.

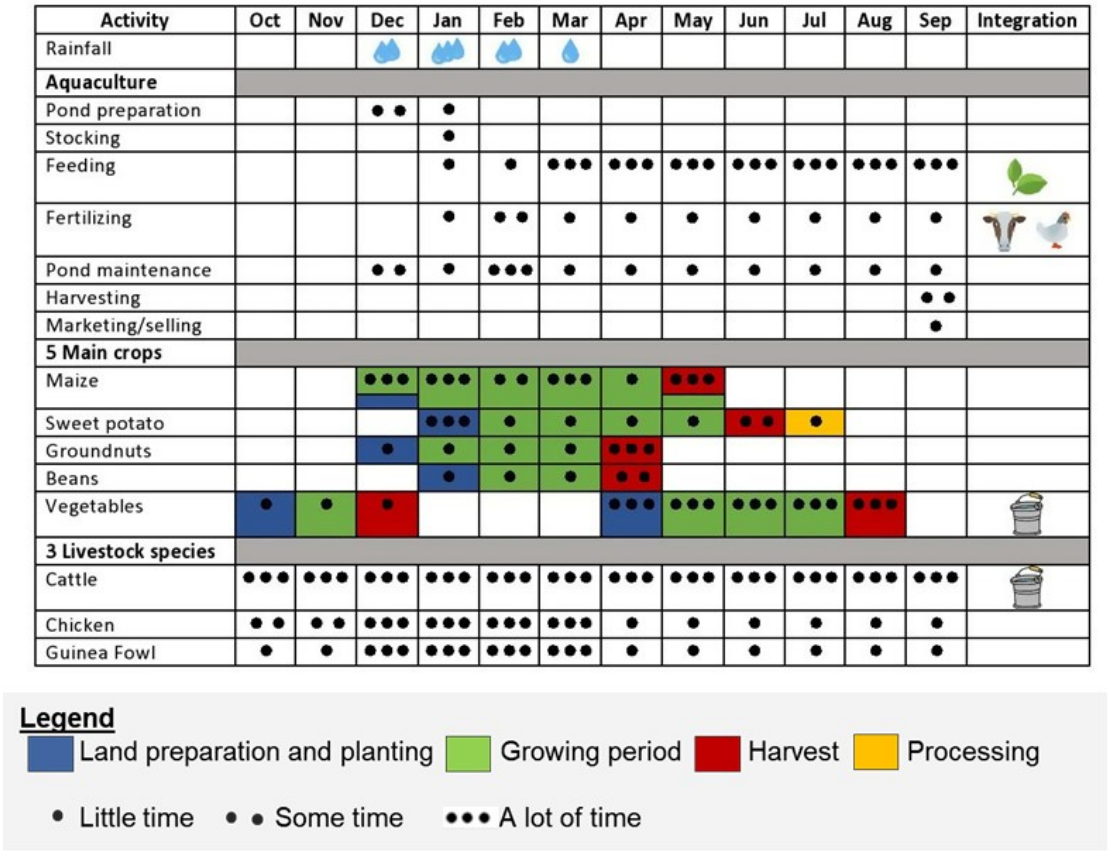

Figure 16: Seasonal calendar for a female farmer from Choma district

Source: own illustration

5.2 Value chain analysis (Output 2)

Since there is a difference between how fish farmers are integrated into the value chain in the northern and southern regions of Zambia, the results in this section are disaggregated between farmers from these two samples. The following section shows quantitative results from the survey on farmers' participation in the value chain. This was followed by qualitative interviews with selected farmers in which they were asked about the process of sourcing their production inputs (seed, feed, fertiliser), their marketing and distribution channels, and any associated challenges and/or opportunities.

5.2.1 Production Input – Seed

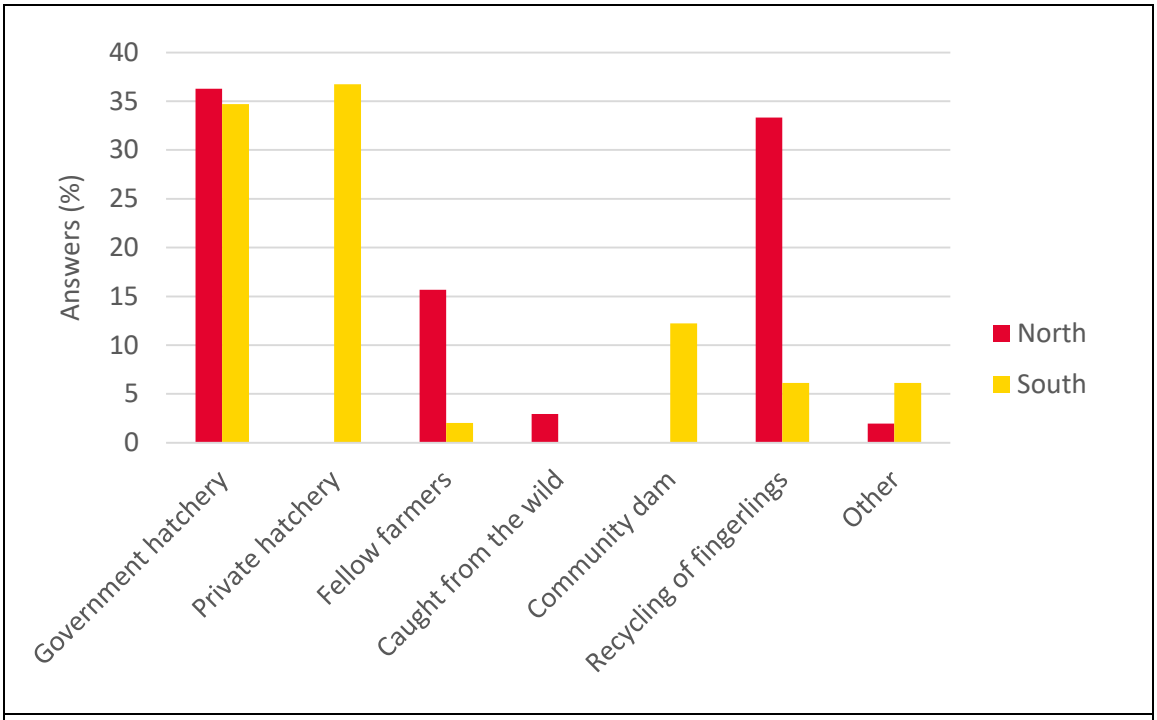

Figure 17: Sources of seed

Source: own illustration

Figure 17 shows that in total, 36 % of farmers (n=102) in the north sourced their seed from government hatcheries, 33 % recycled fingerlings and 16 % received fingerlings from fellow farmers. When assessing the sample of farmers in the south of the country (n=49), seed was sourced mainly from private hatcheries (37 %) and from government hatcheries (37 %), while 12 % of farmers received seed from a community dam[5] and 6 % indicated 'recycling'[6] as a main source of seed.

The data revealed that farmers' ability to source seed depended on their geographic location and wealth. Due to the scarcity of hatcheries in the northern region, access to seed was already difficult due to logistical constraints. In addition, the low asset endowment of fish farmers in the region prevented them from being able to afford seed and restricted their ability to overcome transport barriers. One farmer interviewed in Mporokoso, 180 km away from the nearest accessible hatchery, stated that he intended "*...to pool resources with fellow farmers, but I*

[5] DoF extension officers organised the procurement of fingerlings from the community dam in Mboole.

[6] Recycling in this context means the self-replication of a species in a pond, *i.e.* through breeding.

think it is unlikely I will find enough people who can afford it" (Mporokoso, 28.08.2018). The recycling of seed, *i.e.* allowing the fish to breed year after year, is often the main method that farmers used to acquire fingerlings in that area.

Due to the greater prevalence of private and government hatcheries in the region as well as the higher asset endowments of fish farmers on average, accessing seed was not considered to be a major challenge in the southern region as much as it was in the north. This was expressed for example by one farmer interviewed in Kafue, who stated that "*[We] just phone them [the hatchery] and then go and pick them [fingerlings]"* (Kafue, 16.08.2018). Only a few farmers in that area did not have the means to afford fingerlings and thus relied on recycled seed. DoF extension officers in the region also sometimes facilitated the acquisition of seed from private and government hatcheries.

5.2.2 Production input – feed and fertiliser

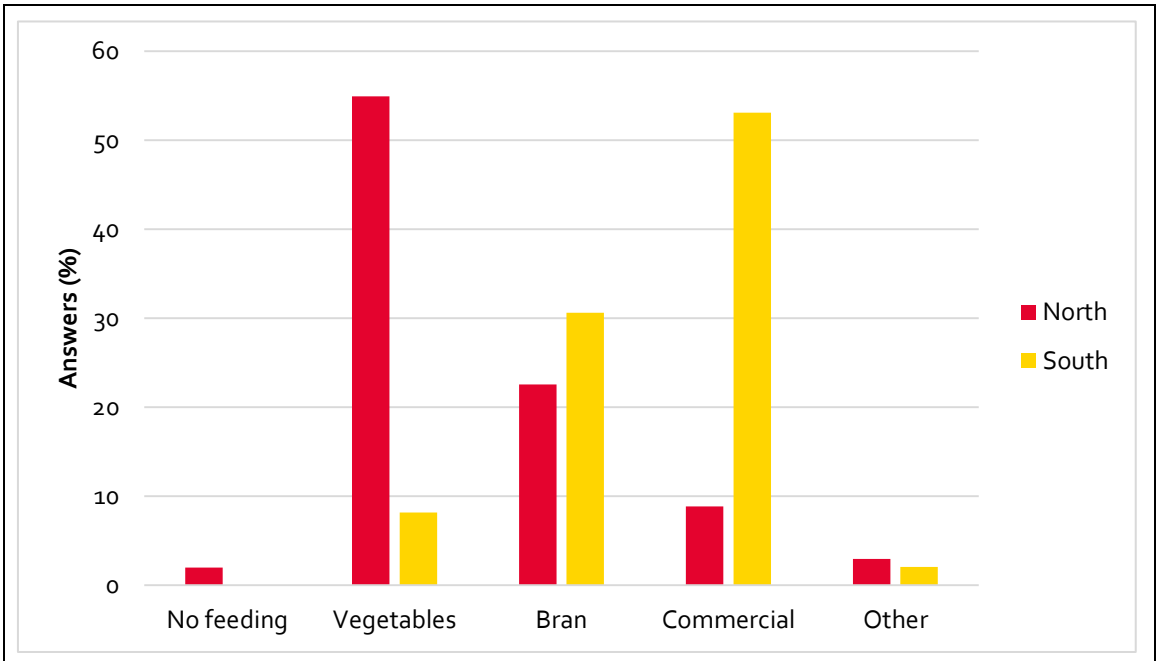

Figure 18: Types of feed and fertiliser

Source: own illustration

As Figure 18 shows, the main type of feed for most farmers in the north was vegetables and leaves (55 %), mainly sourced from their own farm. A further 23 % of farmers relied on maize or rice bran sourced from the own farm, the local mill or market shops, and only 9 % of farmers relied on commercial feed. In the southern region in contrast, commercial feed was the main type of feed for the majority of

farmers (59 %), while 30 % of farmers used maize or rice bran, and the remaining farmers used only vegetables and leaves.

Similar to access to seed inputs, the ability to access fish feed was influenced by a farmer's geographic location and financial endowment. The reason that farmers in the north mostly relied on vegetables rather than commercial feed was because feed outlets for commercial feed are only available in the provincial capital Kasama and fish farmers generally have less financial capital.

In the southern region, where retail shops for fish feed were available in all the district capitals visited[7], most farmers used commercial feed. This is also supported by the fact that most farmers were able to afford commercial feed due to the generally higher endowment of financial capital in that region. One challenge mentioned was that feed is not instantly available at retail shops but has to be pre-ordered a week in advance and that "*access to [fish] inputs is worse compared to offers for other farming activities like maize or cattle*" (Choma, 16.09.2018). Compared to the northern region, there were fewer farmers in the south who were unable to access feed due to a lack of financial resources. One farmer from Choma stated that he had to rely on "*…leftovers from the kitchen and leafy vegetables because commercial feed is too expensive for me*" (16.09.2018).

For pond fertilisation, the majority of farmers in both locations used manure from their own farm or from fellow farmers, as described in one interview: "*Chicken manure from my poultry is enough for the entire production cycles. These are not being paid for, but simply collected. I have a lot of chickens, doves and guinea fowl and so produce enough manure*" (Choma, 16.09.2018).

5.2.3 Distribution/marketing and home consumption

Forty two per cent of farmers in the north said that they mainly sold fish at their farm gate to neighbours and other villagers (see Fig. 19). For 25 % of farmers, the main way of selling was at local markets within or in neighbouring villages. Only 8 % of farmers said that they mainly sold fish from their farm to a trader, 9 % of farmers mainly sold fish to a retailer, which were mostly grocery chains or food shops in the nearest city, and 5 % of farmers did not sell fish at all but used it for home consumption only.

Similar to the north, 39 % of farmers in the southern region sold their fish mainly at the farm gate. In contrast, only 10 % of farmers sold fish mainly at local

[7] Lusaka, Kafue, Chongwe, Choma and Mazabuka districts

markets, whereas selling at the farm gate to traders and to retailers was more prominent (16 % and 22 % of farmers respectively). Similarly, only 4 % of farmers used fish for home consumption only.

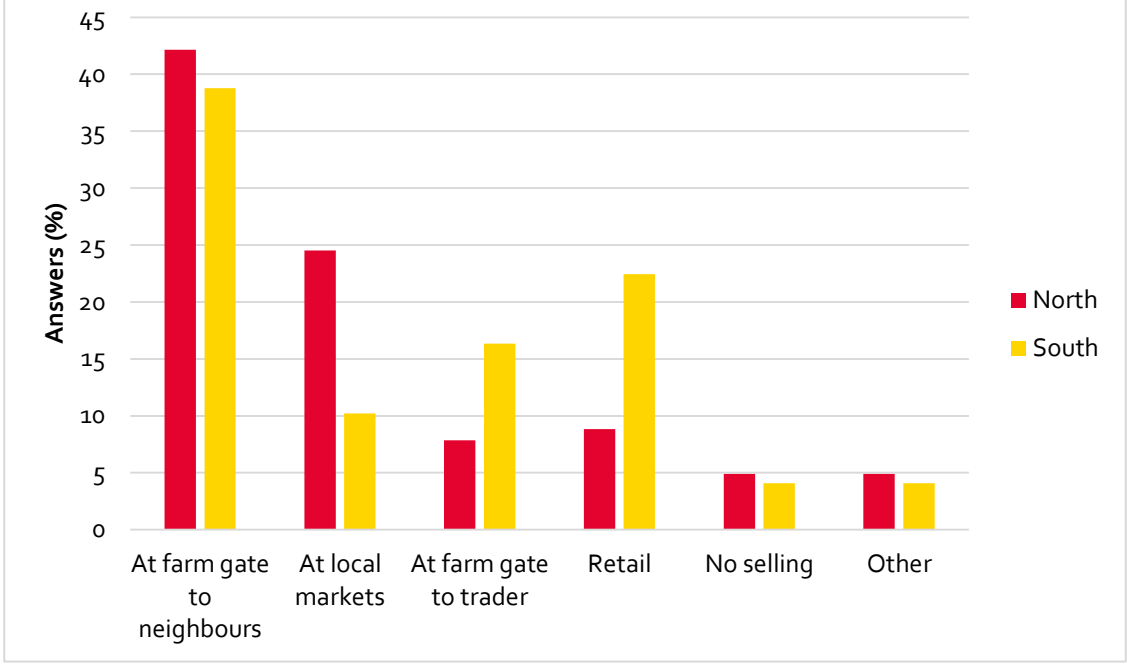

Figure 19: Distribution and marketing channels of fish

Source: own illustration

Most of the farmers interviewed stressed that the demand for fish was high and that they sold their fish easily within a short time. As one farmer in Kasama described the situation: "*Customers were just coming and buying. People from hotels and from restaurants. They just looked at your fish and they would buy it all. There's no problem with the market here. The market is good. I can't keep up with the demand.*" (Kasama, 28.08.2018)

The price of fish varied between farmers and between different marketing channels. While for some farmers, fish was sold at the farm gate for a lower price, others received better prices at farm gate than at local markets. However, only the more intensive systems produced the larger-sized fish that were in demand from most of the commercial retailers. Those who did not meet the standards for selling to retailers and traders mostly sold at the farm gate and at local markets in the villages. "*My fish are not big enough to sell in Choma [to retail] but they can*

reach good prices in the village", explained one farmer interviewed (Choma, 15.09.2018).

Twenty-eight per cent of farmers in the north compared to 16 % in the south stated that they used fish mainly for home consumption.

5.2.4 Regional value chain map

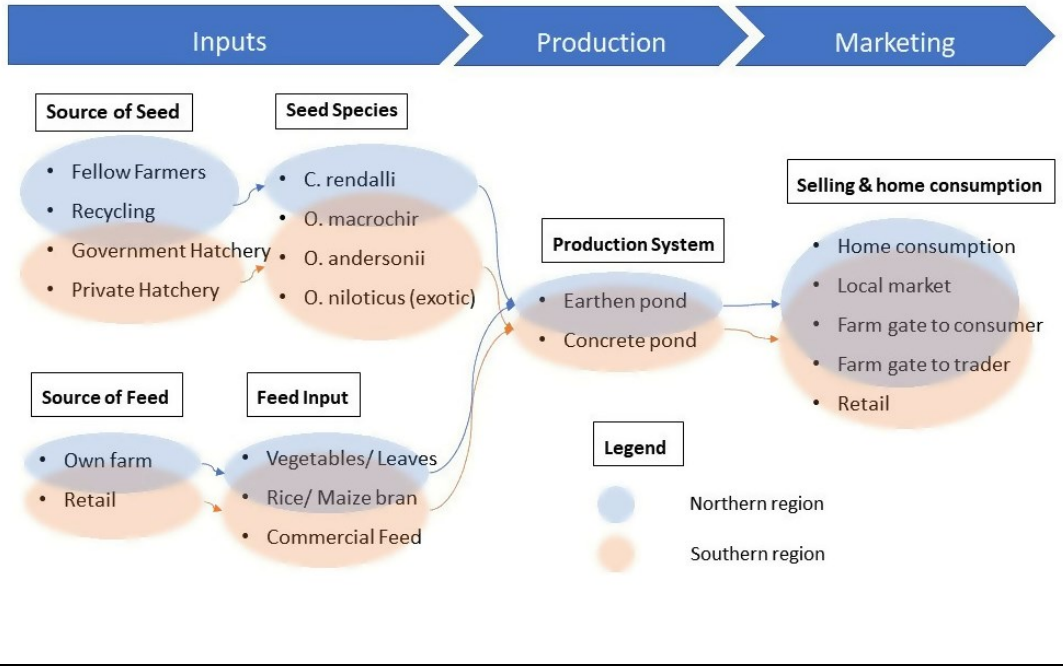

Figure 20: Value chain map

Source: own illustration

Figure 20 shows a value chain map differentiated by region. After analysing inputs, production systems and marketing channels, it became apparent that there were strong regional differences when assessing the value chains for small-scale farmers. Thus a value chain is presented in two strands as one that services more subsistence farmers and the other more 'commercial' farmers. The connection between these types of farmers is then shown and the nodes in each region highlighted in blue (north) and orange (south). By showing the regional differences, the map underlines the influence of farmers' asset endowment and geographical factors on value chain participation. The availability of commercial inputs due to the proximity of farmers to the commercial sector in the southern region is a geographic benefit, as it allows easier access to seed and commercial feed in the area. In the north, by contrast, the low availability of inputs adds to the challenge of a lack of finance to be able to afford commercial feeds. Due to the favourable envi-

ronmental conditions and a long tradition of aquaculture, there are still thousands of farmers in the north compared to just a few hundred in the south (see DoF 2015).

Looking at marketing aspects, farmers in general exploited various market opportunities throughout the country. The regional difference here was the sense that it was hard for farmers to compete with farmed tilapia in the south, which are usually larger in size. Even with access to commercial feeds they found it difficult to produce larger fish. Nonetheless, more formal and direct methods of selling to traders and retailers could be found in the south (*e.g.* contracts, formal relations, *etc.*). In the northern markets, and with the availability of indigenous species, farmers were able to sell their fish at the farm gate and to nearby villages with little complaint. It is clear from both samples that most fish farmers intended to sell fish, and while many farmers consumed some of their fish, the perception was that if fish could be grown more efficiently, it would be easier to sell it.

5.3 Gross margin analysis

The results of the gross margin analysis (GMA) show a diverse range of economic performances for the 13 farmers surveyed. This reflects the low to high production systems and diverse farm characteristics described in the results thus far. GMA also provides an accurate view of production cycles and productivity. Many of the farmers in the GMA sample produced fish with low inputs (on-farm by-products) utilising their own labour. In contrast, some of the higher-producing farmers hired labour and used commercial feeds.

5.3.1 Low and high input production systems

There were clear differences in the profits (turnover minus input costs) of the farmers in the sample (see Fig. 21). For example, farmer N2M (read as 'North Farmer', 'Number 2', 'Male') had costs[8] of ZMW 6,456 (USD 645)[9] and received turnover of ZMW 27,500 from selling fish, resulting in a large profit of ZMW 21,044. This can be considered as a highly profitable farm for a production cycle lasting seven months. Three more farmers (N1M, S1M and S2M) operated their fish farms in a similar way. Nine of the thirteen farmers in the sample made a profit, albeit some from a very low baseline, such as N4F (read as 'North Farmer',

[8] In this example only direct cash was considered. For non-cash calculations, see Annex 4.

[9] ZMW-Zambian Kwacha, exchange rate 1 USD = 10.3 ZMW (average over 19 days from 28.08.2018 – 18.09.2018)

'Number 4', 'Female'), who only made a profit of ZMW 105. Interestingly others made a profit of ZMW 750 with just ZMW 50 of inputs, thus resulting in high gross margins. Some farmers saw a large loss as a result of high production costs, such as S4M (read as 'South Farmer', 'Number 4', 'Male'), who suffered a loss of ZMW 13,776. The GMA provides a deeper understanding of the low, medium and high-producing farmers described earlier.

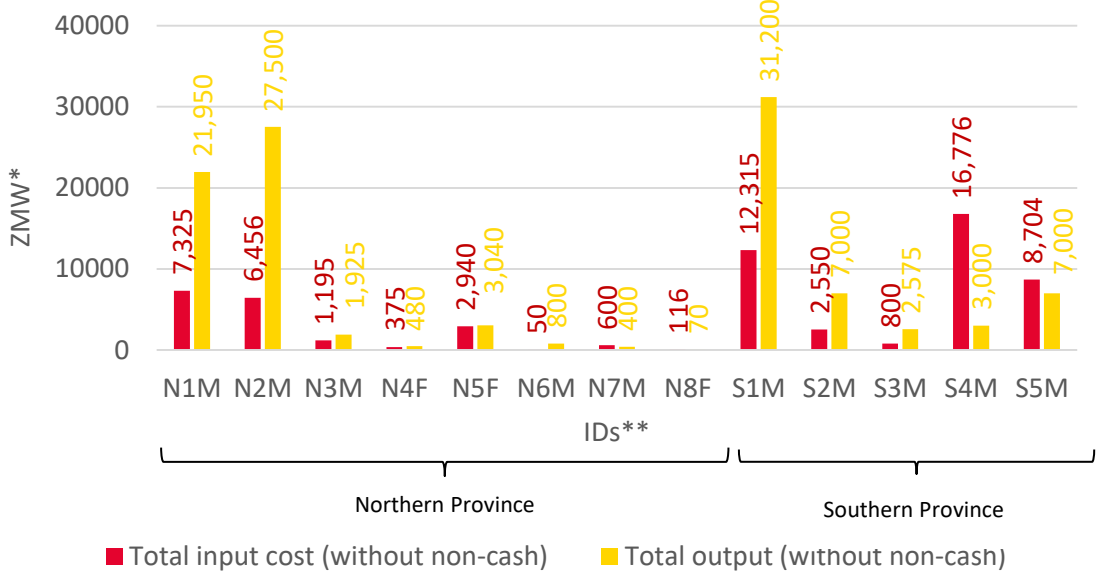

Figure 21: Total input costs and output

*ZMW: Zambian Kwacha, exchange rate 1 USD = 10.3 ZMW (19-day average from 28.08.2018 to 18.09.2018)
**IDs: N1M (North One Male), N4F (North Four Female), S5M (South Five Male) *etc.*
Source: own illustration

5.3.2 Gross margin of different production classes

Table 6 shows the differences in terms of production costs, net cash per cycle and gross margins of three farmers who represented the 'low', 'medium' and 'high' production classes (defined only by total yield produced within the previous 12 months). There were notable differences in the types of inputs utilised by these farmers. As an example, a high producer from the northern region (N2M) had not used any commercial feed during the previous production period, but grew his own soy and maize and produced his own feed. As a result, his input costs were significantly reduced. The feed had a non-cash value, which was excluded from this specific calculation but is captured in a separate analysis in the next section.

The farmer from the "medium production group" (S2M) showed similar characteristics. This farmer had his own milling enterprise and regularly fed his fish with maize bran from his own mill. The non-cash value of the maize bran was not included in this calculation either. Farmer N2M had higher labour costs for farm management activities such as pond maintenance, feeding and harvesting compared to farmer S2M who only paid external workers once (ZMW 300) for the harvesting of fish. Daily activities such as feeding were done by the farmer himself and not included in the calculation[10]. The estimations of cash equivalents to labour costs are added in the next section.

Table 6: Gross margin analysis for low, medium and high production classes

	Low production (N3M)		*Medium production (S2M)*		*High production (N2M)*	
	Amount per cycle	**Total cost (ZMW)**	**Amount per cycle**	**Total cost (ZMW)**	**Amount per cycle**	**Total cost (ZMW)**
Operations						
Fingerlings (number)	400	120	7,000	1,500	3,000	1,500
Commercial feed (kg)	200	860	150	750	0	0
Other feed (soy, maize, maze bran) (kg)	950 Maize bran	155		0	1.680 Soy and maize	0
Animal manure (kg)	300	60		0	2,400	280
Labour costs (feeding/harvesting)		0		300		2,100
Transport (acquire fingerlings; trips to market)		0		0		200
Total production costs (per cycle) (ZMW)		**1,195**		**2,550**		**4,080**
Sales						
Fingerlings (number)			6,000	6,000		
Fish sold (kg)	55	1,925	100	1,000	1,100	27,500
Fish consumed (kg)	0		252		100	
Revenues (gross) (ZMW)		**1,925**		**7,000**		**27,500**
Farm data						
Productivity (ton/ha/cycle)	2.2		4.2		17.8	
Cycle per year	1.7		1.7		1.7	

[10] Farmer N2M spent 315 hours (1.5 h/day x 210 days) feeding his fish. The estimated cost per hour was ZMW 1.9. Farmer S2M estimated the cost of hired labour to feed fish at around ZMW 4.7 per hour.

Operational pond size (m^2)	253		840		675	
Species	*O. machrochir*		*O. andersonii and C. rendalli*		*O. machrochir* and *C. rendalli*	
Gross margin per cycle (ZMW)		**730**		**4,450**		**23,420**
Gross margin per year (ZMW)		**1,241**		**7,565**		**39,814**
Gross margin/revenue (%)		**38 %**		**64 %**		**85 %**
Source: own data						

As shown in Table 6, the high-producing farmer N2M had the highest gross margin, mostly due to his low feed costs. It should be noted that this farmer achieved a relatively high productivity by growing indigenous fish species that have not been genetically improved.

Table 7 displays the economic data and gross margins of two fish producers from the high production class. The table allows comparisons to be made between two farmers who produced relatively similar amounts of fish, but with stark differences in terms of productivity and inputs. It also allows a comparison of the difference between fast-growing *O. niloticus* and indigenous species. The table reveals that farmer S1M performed relatively well with an annual net revenue of ZMW 43,130 producing 1,500 kg of fish from one concrete pond (300 m^2 and about 2 m deep), while farmer N2M produced 1,200 kg from one earthen pond (675 m^2) with a much lower productivity (50 t/ha *versus* 17.8 t/ha respectively). Both productivity rates are exceptionally high and should be met with caution. The comparison shows that production costs led to a higher gross margin for farmer N2m, despite lower revenues and productivity.

Farmer S1M used improved, sex-reversed *O. niloticus* purchased from a private hatchery. The stocking density of his pond was 10 fish/m^2. He harvested all his fish at once at the end of the production period (six months) and then restocked with new fingerlings the following cycle. He sold his fish at the market for ZMW 26/kg, however, he also consumed around 300 kg of fish in his household (five household members).

Farmer N2M stocked 3,000 mixed sex fingerlings of different species, namely *O. machrochir* and *O. rendalli*, in a polyculture system. Two weeks before he harvested his fish, he informed his friends, neighbours and the local church community and mainly sold his fish at the farm gate for ZMW 25/kg. He and his family members (six people in all) consumed 100 kg fish during this cycle.

Table 7: Gross margin analysis of high fish production in Zambia's Southern and Northern Provinces

	Case farmer from south (S1M)		*Case farmer from north (N2M)*	
	Amount per cycle	**Total cost (ZMW)**	**Amount per cycle**	**Total cost (ZMW)**
Operation				
Operational pond size (m^2)	300		675	
Fingerlings (number)	2,800	1,680	3,000	1,500
Commercial feed (kg)	1,350	6,075	0	0
Other feed (soy, maize bran) (kg)		0	1.680 Soy & maize	0
Animal manure (kg)	50	10	2,400	280
Labour costs (feeding/harvesting)		1,100		2,100
Transport (acquire fingerlings; trips to market)		780		200
Total production costs (per cycle)		**9,635**		**4,080**
Sales				
Fingerlings (number)		0		0
Fish sold (kg)	1,200	31,200	1,100	27,500
Fish consumed (kg)	300		100	
Revenues (Gross)		**31,200**		**27,500**
Farm data				
Productivity (ton/ha/cycle)	50		17.8	
Cycle per year	2		1.7	
Species	*O. niloticus*		*O. macrochir* and *C. rendalli*	
Gross margin per cycle (cash)		**21,565**		**23,420**
Gross margin per year		**43,130**		**39,814**
Gross margin/revenue (%)		**69 %**		**85 %**

Source: own data

5.3.3 Relevance of non-cash values

Results relating to non-cash values are provided to illustrate the economic relevance of fish used for home consumption, utilisation of inputs from their own farm and household labour (Table 8). The results of the same medium-sized farmer (S2M) were compared below with non-cash values added (see Annex 4 for more detail).

Table 8: Gross margin analysis with non-cash value (case S2M)

	Revenue		Input costs		Profit	
Cash balance	*cash:*	7,000	*cash:*	2,550	*cash:*	4,450
Gross margin	*non-cash*[11]*:*	7,560	*non-cash*[12]*:*	1,498	*non-cash:*	6,062
Total		**14,560**		**4.048**		**10,512**
					without ncv*	**64 %**
Gross margin in percent					with ncv	**72 %**
Source: own data						

*ncv – non-cash value

The profit earned at the end of the production period was ZMW 4,450 in cash (gross margin of 64 %). If the non-cash values of consumed fish and the inputs sourced from his own farm is included, then the total profit was ZMW 10,512, with a gross margin of 72 %.

This example is especially noteworthy as the household consumed more fish than they sold (by 2.5 times). The non-cash value of eating fish was higher than the sale during this period as the farmer sold his fish below market prices due to a lack of knowledge of where to sell.

In the gross margin analysis (Table 9), the labour cost is also included. In the same case, the farmer paid ZMW 300 once for external labour to help him during harvesting. The farmer estimated that he spent one hour per day feeding fish for a total of 213 hours over the seven-month production period. According to the farmer, he would have paid around ZMW 990 for someone to feed his fish[13]. This amount is therefore considered a non-cash value for labour, as shown in Table 8.

The gross margin results, including cash and non-cash values as well as labour costs, are shown in Table 9, where the value is calculated as the amount (ZMW) per hour of labour and per kg of fish.

[11] From consumed fish.

[12] Maize bran, fertilizer and labour for feeding.

[13] According to one DoF Officer, a decent wage for fishpond management (feeding, pond maintenance *etc.*) in Choma was approximately ZMW 5 per hour.

Table 9: Calculation with labour costs (cash and non-cash) and all non-cash values (S2M)	
Analyses of profit per unit of input and output	**Value**
ZMW/hour of labour	49.4
ZMW/kg fish	29.9
Source: own data	

Table 9 indicates that the fish farmer made a profit and earned ZMW 29.9 per kilogram of fish produced, including the non-cash value of the amount of fish consumed. He also made ZMW 49.4 per hour of labour he put in.

This highlights the relevance of including non-cash values in this context, especially since many farmers provide their own labour and consume their own fish. When compared to tables without the non-cash values (Table 10), it is apparent that the inclusion of the non-cash value could be an important determinant of profitability in this context.

Table 10: Gross margin analysis with and without non-cash values (S2M)			
Analyses of profit per unit of labour & output (fish)	Calculation with labour costs (cash and non-cash) and all non-cash values	Calculation without any non-cash values	Calculation without labour cost and with non-cash values from consumed fish
ZMW/hour of labour	49.4	20.9	68.4
ZMW/kg fish	29.9	12.6	41.4
Source: own data			

Labour seems to be an extremely important cost factor when assessing the results in Table 10. If cash were paid to hired labour, the gross margin (profit per input and output) would shrink from ZMW 68.4 to ZMW 49.4 per hour of labour and from ZMW 41.4 to ZMW 29.9 per kg of fish produced.

5.3.4 Investment cost analysis

An investment cost analysis was also performed with the same sample of farmers. The investment cost is not part of the GMA calculations and can be considered as fixed costs. The analysis revealed that some farmers invested their own time and effort in constructing ponds while others made substantial investments

in labour and equipment (see Fig. 22). The results confirmed that farmers from northern Zambia have less physical and financial capital than those from the southern region. Farmers invested more money in pond construction and water supply in the southern region. Due to water shortages in the latter region, some of these farmers needed to construct a borehole to pump water as well as a furrow to bring water to their ponds. Furthermore, some of these farmers built concrete ponds to prevent seepage.

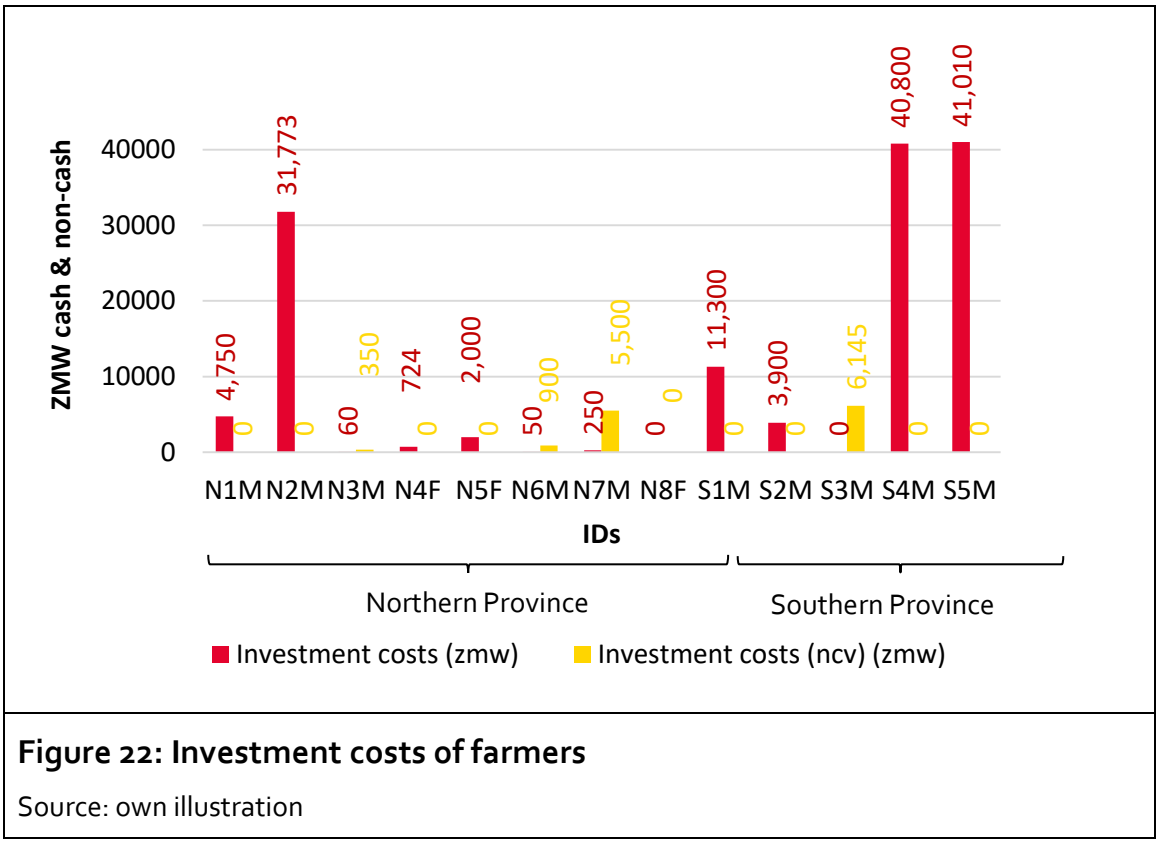

Figure 22: Investment costs of farmers

Source: own illustration

Figure 22 shows that three farmers in the southern region invested more than ZMW 10,000, with two of these farmers investing more than ZMW 40,000. The southern farmers had relatively better farm assets such as electricity and the availability of advanced tools such as pumps. These farmers also hired labour or professional equipment to dig ponds. Even farmers who dug ponds themselves invested more time than farmers in the northern part of Zambia because of the difficult conditions for digging soil. This increased the investment cost when considering the non-cash value of labour.

The investments in pond construction in the north were different. Farmers with ponds along a furrow had lower investment costs and generally larger ponds.

The farmers who lived further away from a furrow tended to have higher investment costs. For example, in one case (N2M), a furrow had to be dug to bring water to his ponds. For the most part though, the farmers in the north invested less in their ponds.

5.4 Intra-household dynamics: Gender and youth (Output 3)

5.4.1 Gendered labour division in the household

This section presents results on the intra-household gender division of labour. Despite the attempt to engage both spouses in a household in the survey, in some cases only one of the spouses was available for interview. Table 11 provides an overview of the gender-disaggregated sample (n=151) in relation to (i) the respondent being the person in charge of fish farming in the household, and (ii) whether they were living in a female-headed or male-headed household.

The stand-out result shows that men made up 75 % of the sample, of whom 92 % were in charge of fish farming. The remaining 8 % stated that they were not in charge of fish farming although all 113 men were living in male-headed households. A quarter of the sample was made up of women, of whom 58 % were in charge of fish farming. Thirteen of these 22 women were living in male-headed households and 9 were in female-headed households. However, of these 9 women, 7 were widowed. The 15 women who were not in charge of fish farming were all in male-headed households. This means that out of the entire sample, only two women, both of whom were in charge of fish farming in their household, were the head of the household without being widowed. The sample of women portrays a more complex picture than that of men, as male respondents generally stated that they were in charge of fish farming and were also the head of their households. To obtain an accurate portrayal of the perceptions of men and women, the following section is disaggregated based on these groups (Table 11). The sample size for each category of women farmers is relatively small and the quantitative findings should therefore be handled with caution.

Table 11: Disaggregated sample based on gender of the respondent, the person in charge of aquaculture and the household head							
Women (n=38)				Men (n=113)[14]			
Women in charge				Men in charge			
Yes (n=22)		No (n=15)		Yes (n= 104)		No (n=4)	
FHH (n=9)	MHH (n=13)	FHH (n=0)	MHH (n=15)	FHH (n=0)	MHH (n=104)	FHH (n=0)	MHH (n=4)
*(FHH: Female-headed household, MHH: Male-headed household)							
Source: own data							

5.4.2 Men in charge of aquaculture

5.4.2.1 Men in charge in male-headed households

Figure 23 below demonstrates the results on men's perceptions of labour distribution in aquaculture. The findings indicated that when men are in charge of fish farming, they dominate certain activities such as acquiring fingerlings and pond preparation. According to this group, men were the main individuals responsible for preparing the pond and acquiring fingerlings in 76.8 % and 87.9 % of cases respectively. Men usually conducted pond maintenance (65.7 %), however women cooperated with men in 25.3 % of cases. Spouses usually did the feeding and harvesting jointly (60.6 % and 61. 2% of cases respectively). In the remaining cases, men carried out these tasks by themselves (29.3 % and 34.7 % for feeding and harvesting respectively). The marketing and sale of fish presented a mixed picture, with men (45.9 %), women (18.4 %) or both (33.7 %) engaging in the sale and marketing of fish. The higher share of women's participation in marketing and selling compared to other aquaculture-related activities is noteworthy.

[14] The discrepancy between the number of male respondents interviewed and the sum of male respondents who were in charge and not in charge is due to missing data.

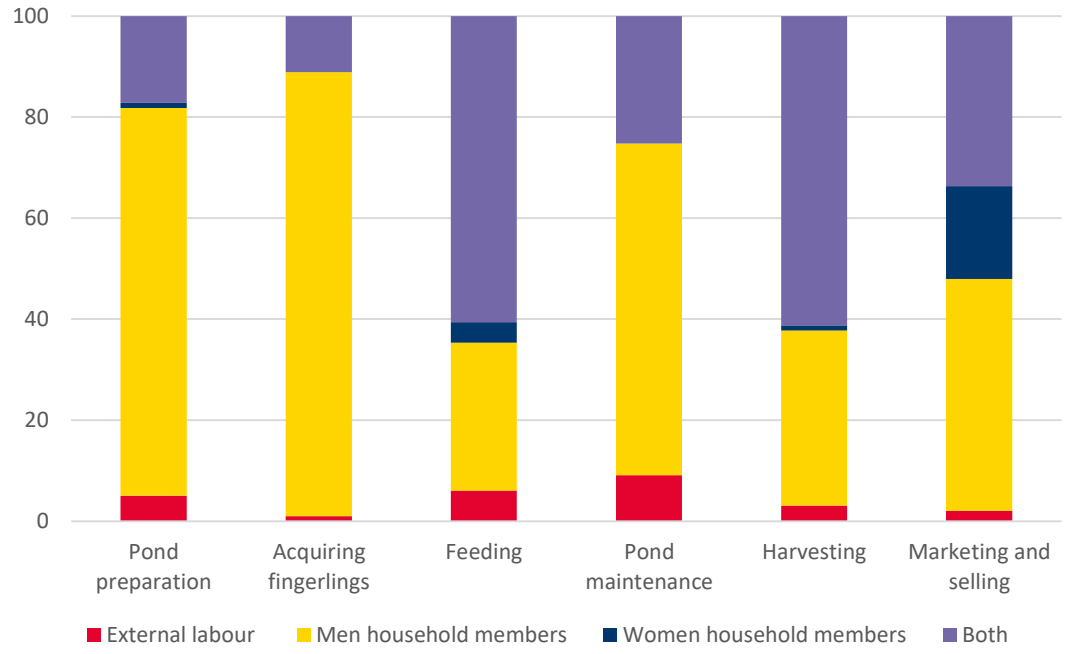

Figure 23: Labour division according to men in charge of aquaculture in male-headed households (n=104)

Source: own illustration

5.4.2.2 Women in male-headed households

Women who were not in charge of fish farming and were living in male-headed households confirmed that men were generally responsible for the acquisition of fingerlings and pond maintenance in 89.7 % and 65.7 % of cases respectively (Fig. 24). However, 28.6 % of women in this category mentioned that they cooperated with their husbands on maintaining the ponds. Approximately 40 % of women who were not in charge stated that both spouses were involved in pond preparation, while 53.3 % said that only men were responsible. Similar to the results above from the men in charge, feeding and harvesting were the activities that were usually done jointly by both spouses. The majority of women (85.7 %) stated that feeding was done jointly, followed by 14.3 % who stated that only men were responsible. Half of the women mentioned that spouses harvested the fish together, while 42.9 % said that men were responsible. According to half of these women, and similar to the perceptions of the men above, marketing was usually handled jointly. The remainder stated that only men did the marketing and selling (35.7 %) or only women (7.1 %).

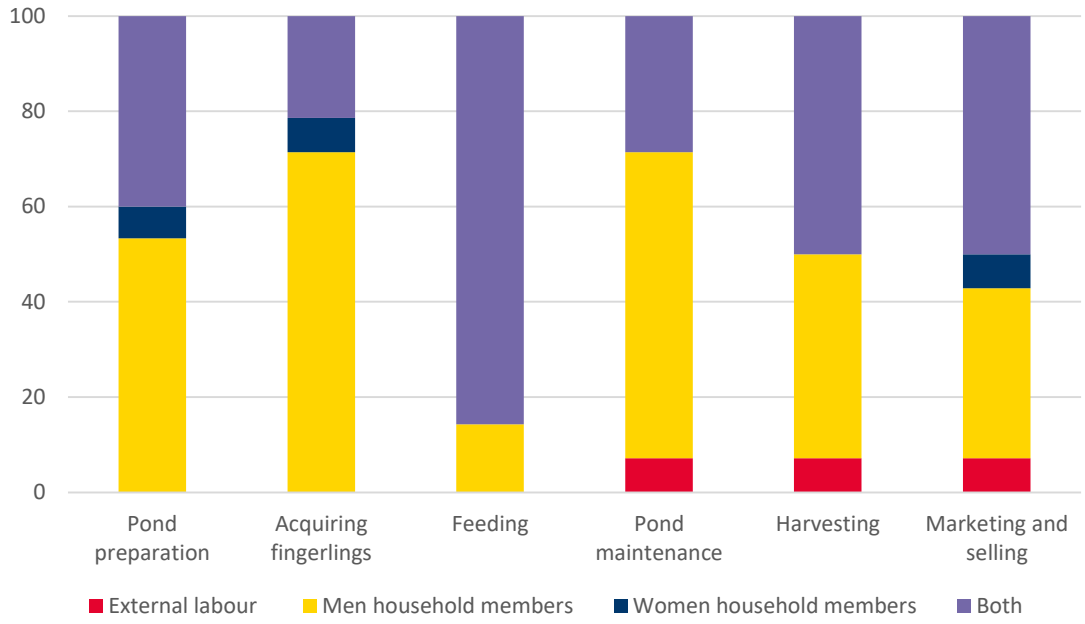

Figure 24: Labour division according to women not in charge of aquaculture in male-headed households (n=15)

Source: own illustration

5.4.3 Women in charge of aquaculture

5.4.3.1 In male-headed households

The picture portrayed by women who were in charge of fish farming in male-headed households differed considerably from those who were not (Fig. 25). Most notably, women were considerably more involved in all activities. According to this group, acquiring fingerlings and pond preparation were the only activities for which women seemed to seek assistance from their spouses. Pond preparation was done by women in 38.5 % of cases, followed by men in 30.8 % or both in 23.1% of cases. Women stated that they were usually responsible for acquiring fingerlings (53.8 %) while some relied on their husbands to acquire fingerlings (30.8 %). The feeding of fish was generally done by women (58.3 %) or both spouses (33.3 %). Maintaining the pond was often the women's responsibility (53.8 %), although it was carried out only by men in 23.1 % cases or by both spouses in 15.4 % of cases. Harvesting was done either collectively (46.2 %) or by women (38.5 %), and harvesting by men was only done in a few cases (15.4 %). Half of the respondents mentioned that they handled the marketing themselves, while 25 %

marketed the fish jointly with their husbands, and 16.7 % said that men sold the fish even though the women were the ones in charge.

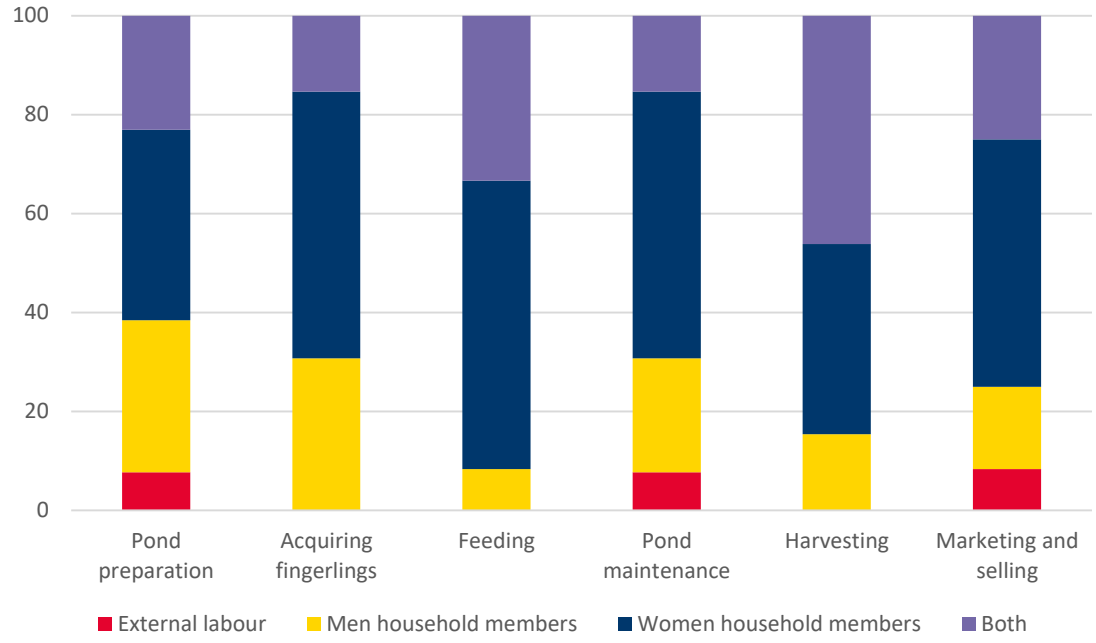

Figure 25: Labour division according to women in charge of aquaculture in male-headed households (n=13)

Source: own illustration

5.4.3.2 In female-headed households

Figure 26 below indicates that in the small sample of women who were in charge in female-headed households, pond preparation was done by female household members, by both male and female household members, or by hiring 'external labour' to the same extent (33.3 % in all cases). External labour refers to labour provided by those who are not members of the household. While mostly insignificant in the other sample groups, the prevalence of externally hired labour was far higher for this group. Bearing in mind that seven of the nine women were widowed, this might indicate that these women were dependent on the labour of men to perform certain activities. While it is unclear whether this was paid or unpaid labour, it does highlight an extra cost of and/or dependency on external labour for this sample of women.

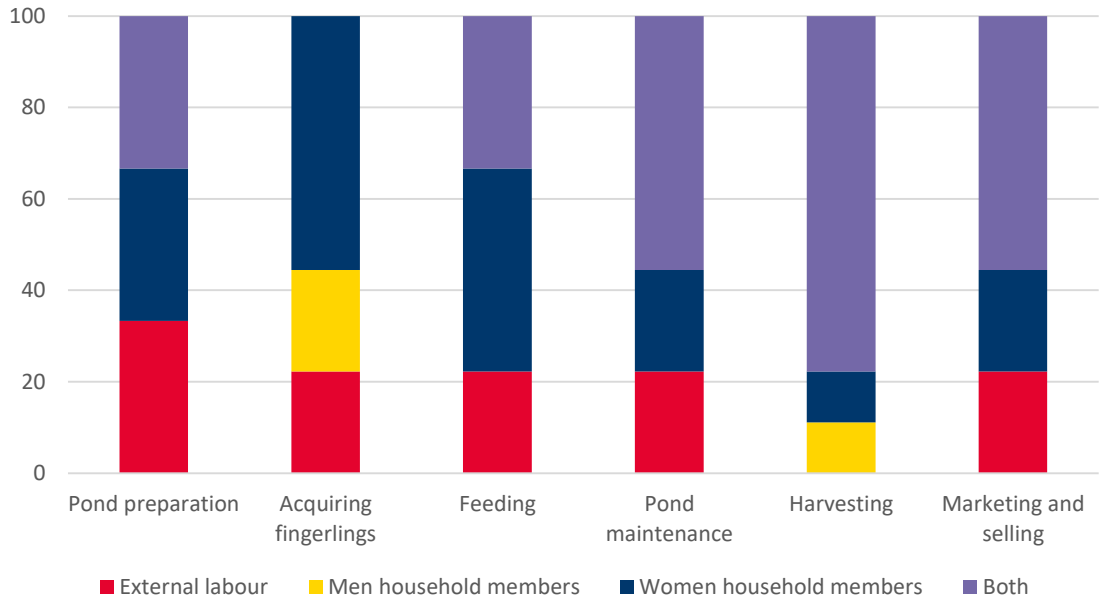

Figure 26: Labour division based on women in charge of aquaculture in female-headed households (n=9)

Source: own illustration

More than half of the respondents in this group said that they were responsible for fingerling acquisition (55.6 %), although the remainder were dependent on men or externally hired labour for this activity. Feeding was generally done by women in 44.4 % of cases, followed by both men and women (33.3 %) or external labour (22.2 %). Men and women usually undertook pond maintenance together (55.5 %), followed by only women (22.2 %) or external labour (22.2 %). Harvesting was mostly done together by women and men (77.8 %). Women and men were jointly responsible for marketing (55.6 %), while only women marketed the fish in 22.2 % of cases or used external labour (22.2 %).

5.4.4 Gender-differentiated focus group discussions

The diverse picture presented in the results of the quantitative surveys was validated during the qualitative inquiry using focus group discussions (FGD). While labour-sharing depended on each household, many respondents cited the high collaboration between women and men in fish farming. However, during a FGD with a group of male fish farmers in Mungwi district, Northern Province, men described acquiring fingerlings as the only activity that was strictly reserved for men. One farmer described his remote location from fingerling providers and his limited access to transport means such as vehicles. He claimed that they needed to travel

long distances by bicycle to collect the fingerlings from the government hatchery in Misamfu, which was seen as being too difficult for women. Women in the women's group, however, stressed that while this was generally the case, they were capable of doing this task as well if necessary. Some women who were in charge of fish farming in female-headed households stressed that they did collect fingerlings.

During one FGD with women and men in the Kingfisher Cooperative in Kafue, men described the selling process as involving a lot of bargaining and that women were generally better traders due to their superior bargaining skills. This may partially explain the higher share of women's participation in marketing and selling compared to other activities related to small-scale fish farming.

In a FGD with female fish farmers in Mungwi district, the participants described very different forms of labour-sharing in the households. While a few women said that their husbands did not show an interest in fish farming, many described fish farming as a household activity with all household members (even children) being involved. The majority of the participants in this FGD were women who were not in charge of fish farming and lived in male-headed households. These women stressed that they contributed to fish farming activities, and a few participants said they were the ones in charge of aquaculture in their household. According to this latter group of female farmers, some said that they would like to have more support from their husbands, especially due to the time constraints women faced, including unpaid household chores such as cooking. Other women in this group expressed concern about men taking over decisions related to fish farming and were satisfied to keep fish farming without too much interference from men.

5.4.5 Youth dynamics in aquaculture

The quantitative survey and seasonal calendars were used to provide insights into youth involvement in aquaculture. This topic was explored using the quantitative and qualitative tools and the results presented below.

The quantitative sample showed that in addition to most farmers being men, they were also predominantly over the age of 50 (the mean age of the sample was 51 years). Only 16 % of the sample fell under the category of 'youth', which covers the age group between 15 and 35 years old. When comparing the average asset endowment of young farmers with those of the rest of the sample, it becomes clear that these farmers had considerably smaller household assets than their older counterparts. Young farmers scored lower on average in all five asset categories (Fig. 27).

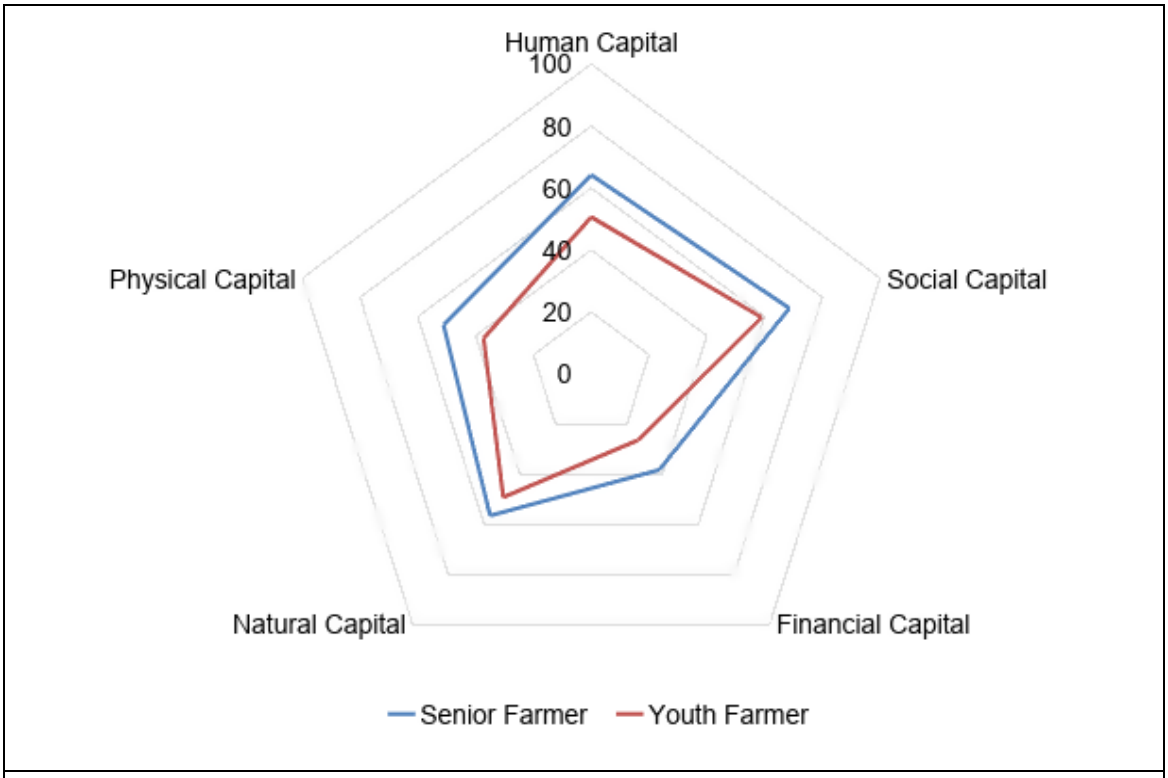

Figure 27: Comparison between the asset endowment of young and older fish farmers

Source: own illustration

In qualitative interviews, fish farmers mentioned several reasons why young people were less involved in aquaculture. Younger farmers claimed that there were little economic opportunities in fish farming and that it could not provide them with a regular income. One older farmer stated that: "*Young people do not see a profit in farming. Youngsters want to have an office job because it is clean and fish farming is muddy. But once they experience the town, they will come back to the lands."* (Kasama, 28.08.2018)

Another young farmer stated that: "*Young people want fast money and have no patience for fish farming. Also the regularity of income is necessary for most."* (Mporokoso, 29.08.2018)

People mentioned that young people were often away from home and this did not allow them to keep and manage ponds regularly. Young people often had farms without vegetable production or livestock and thus struggled to aquire feed inputs such as animal manure (Mporokoso, 29.08.2018). However, young farmers stressed that the availability of land, which facilitates their involvement in fish farming, should be considered in how people engage in aquaculture. Many young people also stated that due to the high level of household involvement in fish

farming, they were already participating in many aquaculture-related activities although they were not necessarily always the ones in charge. In an interview with the Chief Aquaculture Research Officer at the Department of Fisheries, he stated that the government is currently trying to have at least 20 % youth involvement in their projects under a new policy.

5.4.5.1 A case study of an enterprising young farmer

Using the data from the GMA and the seasonal calendar, this section presents the case study of a young successful fish farmer. This farmer was a 28-year-old man living in Mungwi district, Northern Province. He was able to produce 530 kg of fish in the previous year with limited inputs, earning total revenue of 21,500 ZMW and a profit of 7,290 ZMW.

This farmer was one of the few farmers in the sample to earn a living mainly from aquaculture. He organised multiple growing cycles simultaneously in different ponds, which allowed him to market his fish several times a year. According to him, pond preparation, and in particular pond maintenance, were the most time-consuming and labour-intensive activities, therefore he hired labour when needed (see the seasonal calendar below in Fig. 28).

In the previous twelve months, this farmer had harvested his ponds three times. In March 2018, he was also able to generate additional income from selling fingerlings to fellow farmers. In May, he harvested and marketed the fish, with the last harvest taking place in August. He had not harvested any maize in the previous twelve months because he had decided to fully concentrate on fish farming and had not invested any time in maize cultivation in the previous year. This is in stark contrast to the seasonal calendar seen in Figure 16 in Section 4.3.1, and compared to the other seasonal calendars in which most farmers were balancing various livelihood strategies. This particular farmer invested in maize cultivation after making a substantial income from fish farming which he then used to make his own fish feed. He also cultivated cassava and sweet potato and reared chickens, although fish farming was still his primary livelihood strategy. He used some of the profits from selling cassava and sweet potato to hire labour to help net his fish. The case of this particular farmer highlights the motivations of younger fish farmers and their potential willingness to focus on fish farming as a primary livelihood strategy.

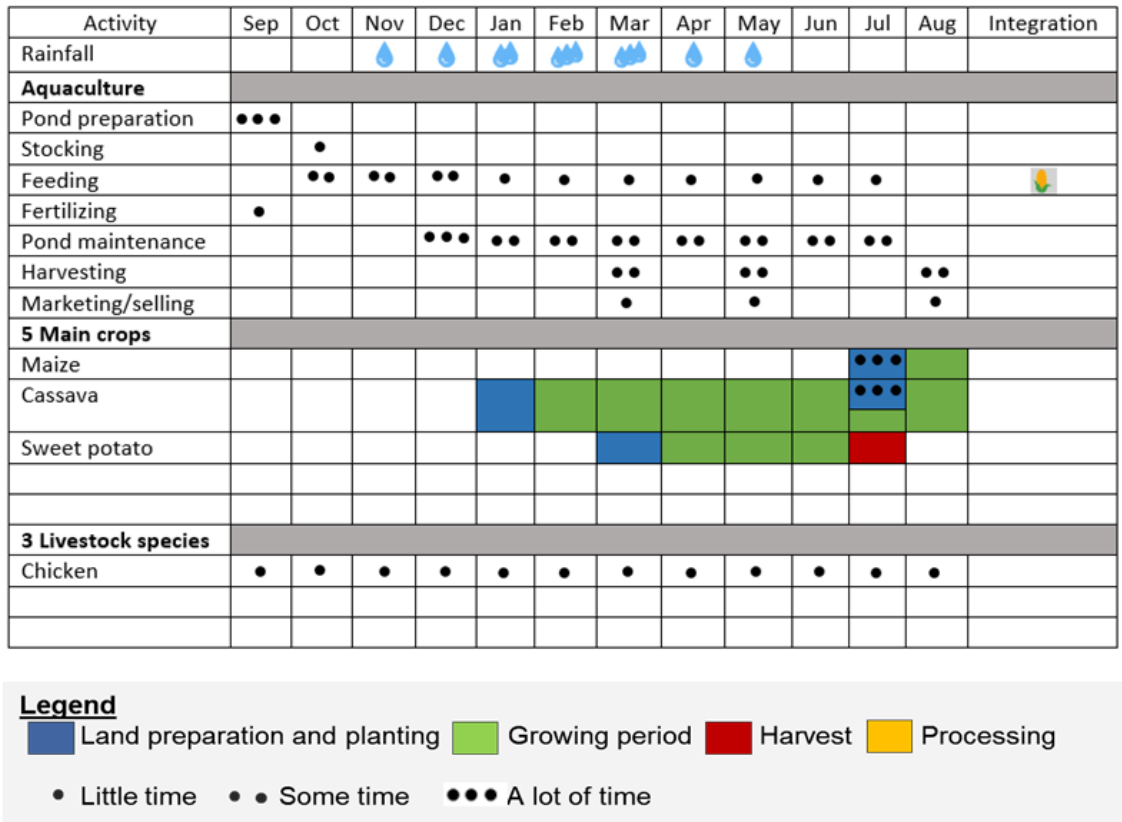

Figure 28: Seasonal calendar of a young farmer from Mungwi district

Source: own illustration

6 Discussion

6.1 Defining small-scale aquaculture in Zambia

There is no clear characterisation of aquaculture systems in the sub-Saharan context. A typology between subsistence and commercial or between rural and peri-urban or between extensive and intensive fails to accommodate the complex livelihood and social-economic dimensions of why people get into fish farming. Fish farmers in the Zambian case are difficult to classify because they differ greatly from one another in terms of the degree of commercialisation, the size of their farms, their prosperity, their production intensity *etc*. According to the DoF in Zambia, the differentiation between fish farmers is based on "size and scale", *i.e.* large-scale or small-scale. According to Kaminski et al. (2018) this is based on total yield alone and does little to denote the intensity, level of commercialisation or socio-economic context of the farmers.

It is not always useful to base such criteria on size, scale, production or productivity. Productivity was notably difficult to assess in the Zambian context. While data were collected on the total area of ponds that were in operation for each farmer, the data collected was not always accurate given that farmers take out fish through partial harvesting and fish were continuously breeding in ponds. Additionally, farmers harvested from multiple ponds and would only sell larger fish while throwing back smaller fish into the ponds. It was not always clear which ponds were harvested. Some ponds were abandoned in certain months but still operational for some months within the 12-month recall period in our method, thus making it difficult to track fish production. Only the GMA was able to capture this data, but it was labour and resource intensive. This means that understanding productivity and resource efficiency presents a challenge and care should thus be taken to also assess the contribution of these systems to farmers' livelihoods and the local economy as a whole.

The most recent typology of the Zambian aquaculture sector has been proposed by Krujissen et al. (2018a) and is based on levels of intensity, degrees of commercialisation, types of aquaculture system and production levels. While this definition provides a clearer picture of the differences between fish farmers in Zambia, it does not take into account the farmers' socio-economic context.

The wealth of fish farmers has been included in other categorisations (Martinez-Espinosa 1995; Kassam & Dorward 2017). Martinez-Espinosa (1995), for ex-

ample, has defined two types of rural aquaculture: the "poorest of the poor" farmers, who operate a low input/low output system and mostly consume their product, and the "less poor" (or what could be called "better-off") farmers who can afford more costly inputs and produce more fish that is sold for profit. In other studies, this can also be defined as categorising the sector between "commercial" and "non-commercial" farmers (Moehl et al. 2006, Ridler & Hishamunda 2001). According to the definition, non-commercial farmers have various motivations, such as producing fish for home consumption, selling to neighbours or as a diversification strategy, whereas commercial farmers primarily produce fish for the sole goal of maximising profit (Moehl et al. 2006). Such definitions generally fit the categorisation provided by Kruijssen et al. (2018a), although no research has been undertaken to examine the wealth or livelihoods of these farmers.

The present study combined different aspects of the above-mentioned criteria and characteristics to show the diversity of Zambian small-scale fish farmers. Although production (*i.e.* total volume produced) was used as a proxy to differentiate between three groups of farmers (low, medium and high producers) we make the case that this is not always a useful indicator for grouping farmers. Therefore, wealth (in the form of asset endowments), livelihood strategies and the nexus with the aquaculture value chain in particular were included in this analysis, along with how these may relate to specific characteristics of their aquaculture systems, including production volumes. To include levels of commercialisation and intensity, the farm score was introduced.

As shown in the results, the majority of this sample (69 %) had produced less than 100 kg of fish in the previous 12 months with relatively low asset and farm scores. According to the literature, this group would most likely be defined as semi-subsistence or non-commercial fish farmers who have low-intense, low-cost systems with a low asset base, using their fish mainly for home consumption based on a diversified livelihood strategy. Even if the low-producing farmers fit within the proposed definition of non-commercial fish farmers, many of them (63 %) stated that their primary motivation for farming fish was to sell for markets and generate a profit. According to Moehl et al. (2006), it is no surprise that even non-commercial fish farmers want to make money from their fishponds. However, these farmers do not always manage to operate their ponds as a business and aquaculture becomes a risk reduction strategy among many other small agricultural businesses. Fish ponds tend to operate more as a 'bank' that provides quick access to small amounts of cash when required. This was also evident from the qualitative interviews in which a variety of different farming activities were recorded, and where some farmers stated that they used their fish to pay for school

fees for example. The aquatic produce was still important for home consumption as 76 % of the low-producing farmers in the sample stated that they consumed fish from their ponds at least once per month. It has been suggested that non-commercial fish farmers are usually "smallholder farmers with a fish pond" rather than strictly "fish farmers" (Moehl et al. 2006). Our results confirmed this hypothesis since the majority (66 %) of the low-producing farmers mainly relied on the sale of maize, vegetables and other crops as a first income source.

The sample found very few households (n=9) producing above 500 kg per year that would fit the small-scale commercial definition by Kruijssen et al. (2018). These farmers had a higher degree of intensification and were generally able to use commercial inputs. The high-producing farmers tended to have a higher asset base and were better off, especially in terms of financial capital. This specific result from the sample is supported by other studies that relate wealthier farmers to a higher degree of commercialisation (Kassam & Dorward 2017, Martinez-Espinosa 1995). Interestingly, these farmers did not all rely on fish farming as a first income source but had other off-farm income sources, such as formal salaries or pensions, which enabled them to get into fish farming. Most of the highest-producing farmers in this sample seemed to have other more valuable income sources.

Of interest is also the group of mid-producing farmers who fall into varying levels of farm intensity and who show varying degrees of wealth according to our asset index. In other words, these farmers can be either poor or better off but may produce varying amounts, indicating that even wealthier, more commercialised and intensified farmers do not always produce large yields. This suggests that issues of production could be related to issues outside of the household such as within the value chain or at a policy level for example. When assessing the data in terms of development pathways, it becomes important understand how farmers can transition (upgrade) to the higher-producing categories, if at all, and what barriers they need to overcome to do so.

6.2 Additional farmer categories

The previous section described the distinct characteristics between the fish farmers in this sample according to already existing criteria and definitions. However, the findings from these results showed that beyond that, including factors such as gender or location (*i.e.* rural *vs.* peri-urban, or Northern Province farmer *vs*. Southern Province farmer) was also critical in any characterisation of farmers.

Such criteria are important when deciding which farmers to target for different interventions or policies. Interventions need to be tailored to specific contexts so that they can be effective for specific groups of farmers in varying locations. This section goes into more detail on these factors and why they are important in building profiles of farmers to target tailor-made interventions or strategies. These results highlight how opportunities and challenges are determined by four main factors: (1) wealth, (2) location, (3) gender and (4) age.

i) Wealth (asset-base)

As seen in these results, higher-producing households were better equipped with financial, physical and natural capital than lower-producing households, whereas no major differences were found in human or social capital. It can be assumed that the more financial and physical capital a farmer is endowed with, the higher the likelihood that larger yields are produced. Financial capital can be an advantage to a farmer with regards to making cost-intensive investments in the fish farm prior to starting production (*e.g.* pond construction), and also acquiring cost-intensive inputs such as high-quality seed and feed. Endowments of physical capital may be an advantage, especially regarding the availability of equipment, tools and electricity. Natural capital such as access to land and water was also revealed to be a critical factor. Since many of these factors are cost-intensive, the combination of physical and financial capital may have the strongest influence on the performance and resilience of a fish-farming household.

Fish farming, however, can offer different opportunities for asset-poor and asset-rich households. While the majority of the sample produced less than 100 kg of fish/year, fish farming was still recognised by interviewees as an opportunity to improve household income and contribute to food and nutrition security, irrespective of household wealth. Households described fish farming as financially lucrative and less labour-intensive than other forms of agriculture, and thus as an attractive livelihood strategy in which to invest their financial resources. While resource-poor households may generally produce less than resource-rich households, they can still generate some profit from fish farming, utilising their labour and fitting fish farming into a diverse portfolio of livelihood strategies. This diversity further provides them with greater access to protein-rich animal foods as well as to a high-value product that can sustain a household during various economic shocks.

Evidence from these results suggests that a resource-rich household's ability to invest financially in fish farming and be well equipped with physical and natural capital does not always translate into higher productivity. The GMA confirmed

that some poor farmers were able to produce as much as wealthier farmers and/or match the productivity of their systems. This implies that there is also a knowledge (training, skills) gap for farmers. Using inputs in an effective way seems to be a challenge, which may also be connected to challenges in the distribution of information through extension services.

ii) Location

In terms of geographic site and proximity to inputs, services and markets, 'location' is another important factor when profiling fish farmers. Farmers' location can both determine the environmental conditions needed for production, as well as the level of participation in the value chain. The study suggests that natural conditions in Northern Province are generally more favourable for fish farming than those in Southern and Lusaka Provinces. A general lack of access to perennial rivers or streams and poor soil quality in the south pose a challenge for fish farmers as they may incur additional costs in securing water (*e.g.* by digging boreholes or by buying plastic liners to avoid seepage in their ponds). According to Namonje-Kapembwa & Samboko (2017), water shortages are a major challenge faced by fish farmers in other drier areas of Zambia who cannot rely on groundwater resources during the warm season and in drought years. Some farmers may resort to capital-intensive solutions such as pumping water to their ponds if they can afford it, as pointed out in some of the interviews with farmers in Southern Province.

Location was also a decisive factor in determining farmers' integration in the value chain. The proximity to urban markets and access to transport are important considerations in farmers' participation in the value chain. According to the data, access to commercial feed and quality fingerlings in the north of Zambia was more limited than in the south due to the absence of feed suppliers and private hatcheries. Kaminski et al. (2018) report that 44 % of small-scale fish farmers in Northern Province sourced their fingerlings from fellow farmers, followed by 24 % who receive their fingerlings from development organisations, while no mention is made of acquiring fingerlings from private hatcheries. This was confirmed by the results from the present study. Genschick et al. (2017) substantiate these results by stating that there is better access to input and output markets in Lusaka and Copperbelt Provinces, which further promotes the integration of small-scale fish farmers into the value chain. The emergence of foreign feed companies such as Aller-Aqua and Skretting in Southern Province seems to provide opportunities for small-scale farmers to access high-quality feed. While it is important to note the differences in availability of fish feed in different regions, it is also worth em-

phasising that this does not necessarily translate to accessibility, which is based on a farmer's ability to procure and utilise inputs, *i.e.* linked to the 'wealth' category above among many other factors such as road or transport access. It is also important to stress that many farmers had relatively high gross margins without utilising commercial feeds and that knowledge and skills can be as important as commercial inputs.

iii) Gender

Gender plays an important role in the profiling and characterisation of fish farmers. Women and men farmers face different challenges while farming, as well as different barriers to entering the sector. Despite actively trying to target women in the present study's sampling strategy, fewer than a quarter were found to be actively fish farming, and even fewer were responsible for fish farming in the household. While the sample was not representative, it does suggest that fish farming in Zambia is gendered. Nsonga (2015) reported that only 7 % of a study sample in Mbala and Luwingu districts in Northern Province were women. A different study in the same region also indicated that men comprised the majority of fish farmers in the relatively small number of households who adopted fish farming as a livelihood strategy (Cole et al. 2016).

The results of the present study show that female fish farmers faced a broader range of problems compared to their male counterparts, especially regarding laborious activities such as digging and maintaining ponds, which can inhibit women from successfully participating in aquaculture. Many women were dependent on men from their households or on hiring external labour for some tasks such as pond construction and fingerling acquisition. According to Cole et al. (2016), most farmers, especially women, lack adequate access to fingerlings and improved feed despite the abundance of available land. This study was not able to explore *why* women may be more constrained than men. It is believed that certain harmful social norms and beliefs can limit women's participation (Cole et al. 2016). However, there were cases of women who actively participated in fish farming, especially in poorer households where fish farming was one of many livelihood options and where women and youth in particular did gardening and other activities close to the household.

iv) Age

The majority of the farmers in this sample were over the age of 50 and thus a person's age is another defining factor for involvement in the sector. The limited participation of young people in aquaculture has also been reported by a study on small-scale fish farming in Central, Lusaka and Copperbelt Provinces where the

average age of fish farmers was reported to be over 50 (Namonje-Kapembwa et al., 2017), similar to the present study. In contrast to older fish farmers who may be able to invest their savings or pensions in aquaculture, young people may not have the same opportunities or access to assets, which impedes their participation in aquaculture. A recent study shows that although aquaculture can offer employment opportunities for younger people, challenges such as the high costs of inputs, low supply of fingerlings and land tenure insecurity continue to prevent them from engaging in fish farming (Machina et al. 2018). However, there may be opportunities within the sector for youths to specialise in fish farming and approach aquaculture as their main livelihood strategy rather than as a fringe activity. The example of one young farmer in particular from this sample who made considerable profits by concentrating on fish farming suggests that younger farmers may be more willing than older farmers to forgo traditional agricultural activities such as maize farming in favour of aquaculture.

6.3 Summary of challenges for different groups

The data from this study confirmed that most farmers broadly fell into the semi-subsistence fish farmer category presented by Kruijssen et al. (2018a). Some farmers, such as the 'medium' producing farmers in this sample, may fall somewhere in between, but have a higher chance of transitioning into the small-scale commercial category. When including wealth, location, gender and age as factors, further sub-groups can also be created. There were a number of challenges that have been discussed above with regards to each of the factors, and each group will have different types of struggles and capacities to overcome these challenges. For example, a female farmer in the north may face different challenges than a male farmer in the south, depending also on their age and wealth *etc*. It is essential to highlight some of these stark differences in any characterisation of fish farmers. This report does not attempt to create these groups but merely states that these are factors to consider when profiling groups, and that farmers would fall somewhere in the continuum already presented by Kruijssen et al. (2018a). Below is a summary of some of these challenges, acknowledging that the above profiling categories could play a role in how they are experienced by farmers. The challenges faced by the small-scale sector in general are:

- **Access to inputs:** This is a challenge faced by almost all farmers, especially in accessing seed, feed and services. Farmers in the south have different input demands than those in the north. Women farmers may have additional

struggles in accessing certain inputs compared to men. The same may apply to younger farmers in certain areas.

- **Access to financial and physical capital:** This is a struggle especially for poorer farmers. Nonetheless, wealthier farmers may also struggle to attract additional investments for their farms. Women and young farmers may be even more unlikely to access financial services.
- **Access to training, knowledge and skills:** Many farmers still lack the basic knowledge to farm fish. Experienced farmers lack the knowledge and skills to upgrade their farms (*i.e.* incorporating commercial feeds or sex-reversed fingerlings, business skills *etc.*).
- **Environmental conditions for fish farming:** Access to natural capital (land and water) is a critical entry point for aquaculture. Some areas such as the north of Zambia seem to have an advantage, although improved, fast-growing strains of fish are allowed for culture only in the south. Poorer people as well as marginalised groups such as women and youths may have less access to land.
- **Infrastructure for fish farming:** Roads, electricity and access to other physical assets are very important for aquaculture growth and most people in this sample lived in very isolated locations.
- **Lack of markets:** While most farmers indicated that they are able to sell their fish, the market for smallholder farmers is still under-researched and it is unclear what role different producers can play in the current fish market in Zambia.
- **Social norms and beliefs:** Norms and beliefs around aquaculture as a livelihood strategy as well as the participation of women and young people in fish farming can be a constraint. Access to assets or decision-making powers can also be governed by certain social belief systems.

6.4 Intervention areas

This section introduces four main areas of intervention based on the study's analytical framework in which it is argued that households (women and men) practise fish farming to produce fish as part of a broader livelihood system. Dynamics within the household may influence the perceptions, motivations and capacities of women and men to farm fish. Each household is equipped with a certain asset base that influences the household's capacity to farm fish, including the ability to link with various upstream and downstream nodes in the value chains. This livelihood and value chain nexus falls within broader agro-ecological and so-

cio-economic drivers. It is argued that interventions can be found in four main areas, namely within the production system, the livelihood (asset) system, value chain linkages and complex intra-household dynamics, the latter of which are shaped by various socio-economic and cultural factors. A brief explanation of these areas is found below:

i) Production systems:

Production systems can be improved for further intensification and more effective resource use. Interventions at production level include optimising certain products and processes for improved efficiency and gains. Such challenges and solutions are usually identified through more technical assessments and in turn require technical solutions (*e.g.* improved management practices, improved processes such as transportation *etc*.). The main objective is to guarantee more productive systems tailored to the needs of fish farmers.

ii) Livelihood strategies (household assets):

The livelihood context of farmers and their asset base is a primary factor that is not often included in assessments of small-scale farmers in Zambia. More holistic approaches need to consider the asset endowments of farmers as well as the livelihood strategies that they employ. Examples from this study have shown that there are certain assets that may contribute to higher fish production, most notably shown in the differences between production classes and their access to financial and physical assets. Improvements in farmers' access to social, physical and financial capital can lower entry barriers and make farmers more productive. Solutions should fit into the livelihood strategies of fish farmers, taking all their activities into consideration.

iii) Value chain linkages:

This study's analytical framework highlighted the important nexus between farmers' livelihoods and the value chain which they operate in. The results showed that despite some farmers having relatively high endowments of assets, they can still produce low yields. This indicates that the challenges may lie at the value chain level and not at the production level. It shows that there is a host of value chain challenges faced by different farmers, mainly in accessing inputs such as feed and seed. Interventions in value chains could require the involvement of stakeholders who govern various parts of the chain (*i.e.* government, NGOs, farmers, business, consumers *etc*.).

iv) Intra-household dynamics (gender and youth):

Many interventions tend to favour technical solutions over social ones. These results show that there are complex social relations within and between households or even with how individual farmers interact with other value chain actors. These interactions are often based on social systems and sets of beliefs, values and norms that govern such relations. The data in this study show that gender and age are key concepts that can set predefined norms and roles for women and men, as well as the elderly and the youth, in how they engage with aquaculture. Interventions that acknowledge these differences and aim to counter any negative constraints can also make greater impacts on productivity and total production as well as ensure better adoption rates of any technical interventions.

6.5 Combining areas of interventions with farmer profiles

Building profiles of farmers and assessing how different factors affect the capacities and subsequent opportunities and challenges for a specific farmer category is critical for maximising development impact. These factors interplay and cross many intervention areas. As a tool of analysis a matrix was designed for profiling farmers and assessing their challenges and opportunities (see Fig. 29). This could be useful in the planning and implementation of single interventions. It could also be used as a method to assess the capacities of farmers and look for potential solutions to various problems at different levels.

Wealth, location, gender and age are included as key variables in any initial characterisation of farmers. This can help build profiles of farmers and highlight individual needs and challenges as well as set the scene for determining tailor-made interventions for specific target groups. The matrix below showcases how each of the profiling characteristics can cross between the different intervention levels. The matrix in the example below is more useful as way of thinking about how to categorise farmer systems and their challenges in order to identify solutions. The following section uses this matrix to present various tailor-made recommendations.

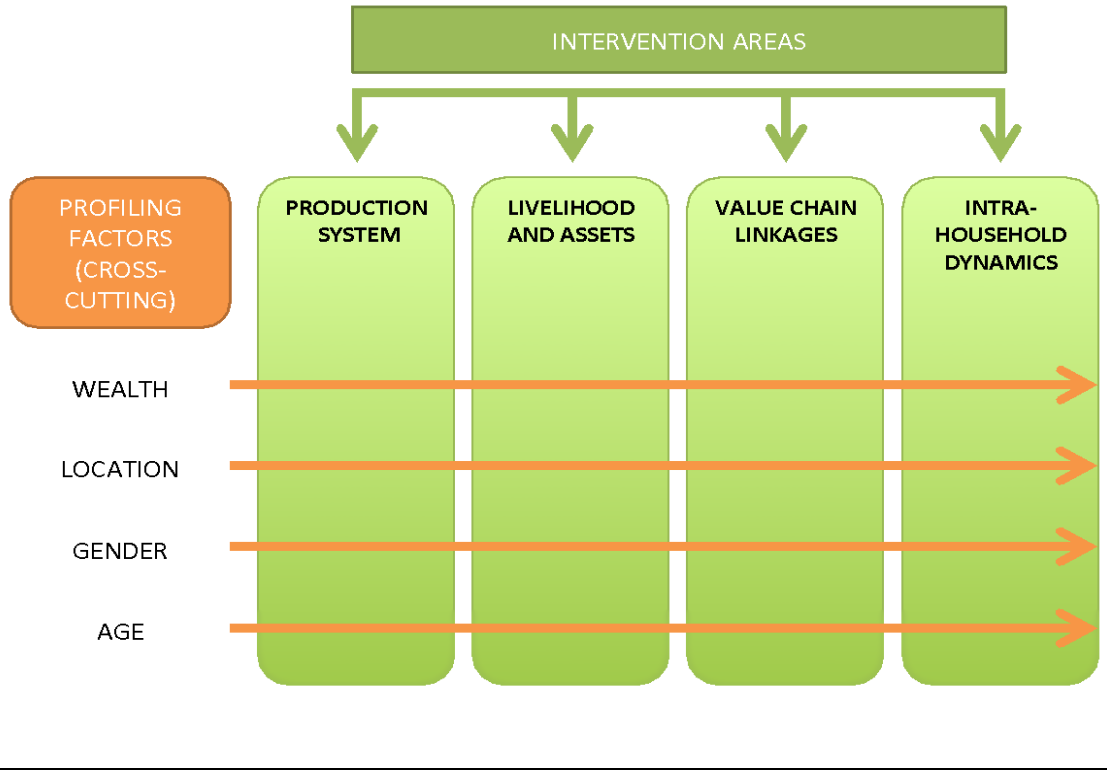

Figure 29: Farmer profiling and intervention matrix

Source: own illustration

7 Recommendations

This chapter highlights the priority groups that should be targeted for greater development impact and then follows up with some practical ideas at different levels. Many of these ideas emerged from the researchers' time in the field engaging with farmers and key informants and seeking to find practical solutions to various challenges that were uncovered. The ideas come from within the SLE research team as well as from WorldFish scientists, the Department of Fisheries staff, private sector actors, various experts and the literature.

7.1 Priority target groups

Small-scale farming in Zambia must increase production to be able to align itself with current growth trajectories seen in the aquaculture sector as a whole. The results show that there is a small sample of better-off farmers who engage in aquaculture relatively successfully. However, most farmers are poor and still struggle to produce large yields. If the objective is to alleviate poverty through aquaculture development, these farmers need to be targeted to be able to increase production and generate wealth. Any interventions that would work with better-off farmers should not be to the detriment of the prospects of poorer farmers. These interventions need to be inclusive of marginalised groups and ensure social wellbeing. It is proposed that the following three groups should be a key priority in Zambia:

- Poor farmers: Most farmers in the country are found in rural areas and could be regarded as the "poorest of the poor". Interventions should aim to be inclusive of this group of farmers, especially those in areas such as Northern Province where there is a greater reliance on agriculture and natural resources for livelihoods. Any intervention should aim to be "pro-poor" and allow these farmers to upgrade their systems and improve their overall performance. It is acknowledged that in some interventions, in cooperation with the private sector for example, these groups may be excluded because of their limited capital and purchasing power, however this only further reinforces the importance of developing innovative approaches that allow poor farmers to adopt aquaculture as a vehicle to escape poverty and increase food and nutrition security. The agro-ecological conditions (*i.e.* location) for fish farming need to assessed for these farmers since the availability of natural and physical capital is also important. We did not include either farmers in the north or the south as priority groups since neither should be

excluded and both have potential according to their particular agro-ecological area.

- Women: Aquaculture seems to provide women with a viable economic opportunity as it is generally carried out close to the homestead, is comparably labour-extensive and is potentially more profitable than other agricultural activities. Nevertheless, there are still many barriers to women entering the sector, namely access to and control over technologies and knowledge/skills, as well as harmful gender norms and beliefs that constrain their participation. Gender-transformative approaches are needed to reduce such barriers for women and create an environment that enables more women to participate in small-scale aquaculture in Zambia. Such approaches should always look to include men in order to drive sustainable social change. Intra-household relations must be considered to ensure women's participation in aquaculture. Fish farming should be considered a "household" activity, especially for rural, poor farmers who adopt aquaculture as part of a wide array of livelihood strategies. For women who are married, higher levels of cooperation between spouses and family members on aquaculture-related tasks could be promoted in tandem with any other approaches/technologies that are implemented.

- Young people: Older farmers overwhelmingly dominate fish farming in Zambia, with little evidence of this being transposed to future generations. Offering avenues for young people to enter aquaculture could help the sector grow. Tackling certain cultural and social norms and beliefs is likely to be a critical aspect when targeting this group.

7.2 Practical intervention priorities

This section focuses on intervention priorities that reflect those in the matrix and bear the above target groups in mind. Some interventions overlap between groups and intervention areas and it is argued that this should be a desirable objective for any intervention. No intervention should be introduced in isolation and ideally a basket of technologies and approaches are used together, ranging from technical approaches to those that also tackle more complex social issues. These interventions should not only be focused at the production level but also take the greater system into account, including livelihoods, assets, value chains and inter-household dynamics (*e.g.* social and behavioural issues). The socio-economic and biophysical factors that drive these systems need to be considered. A discussion

follows about interventions at different levels but also shows how they can be combined with other interventions.

7.2.1 Production systems interventions

- Promotion of fertilisation

There is evidence that shows increased growth rates for tilapia when ponds are well fertilised, *e.g.* by animal manure. Through fertilisation, the natural productivity in ponds is boosted and there are enough natural foods for fish. Commercial feeds can be applied to boost growth at the end of the growing period. This method will benefit less wealthy farmers who cannot afford expensive commercial feed for the duration of the growing period as well as fish farmers who are located in the north, where access to commercial input is still difficult. Training on this practice can be especially useful in areas where enough fertiliser is available from livestock manure, for instance in southern Zambia. Such systems need to consider the livelihoods of farmers and in particular seek out those who are able to engage in animal husbandry. For those who cannot utilise their own farm, the value chain needs to be assessed for fertiliser and feed inputs and for whether they are available and accessible for poor farmers, including women and young people.

Challenge	Commercial feed too expensive
Objective	Ensure fish grow to a large size while minimising input costs
Target groups	Less wealthy farmers who keep livestock or can afford to buy animal manure and commercial feed, women farmers, young farmers
Location	Applicable in regions where commercial feed and animal manure is accessible; markets where larger fish are in demand
Women and youth	Women and youths should be included and can link up with farmer field schools and other intra-household interventions
Specification	Only one type of commercial feed (finisher) is necessary in combination with effective fertilisation
Benefits	Less wealthy farmers can grow large fish with reduced input costs

- Polyculture systems (mixed and/or new species)

Polyculture systems combine a number of different species in one system at the same time. In general, such systems can increase total productivity in ponds if suitable species are combined that complement one other and exploit different trophic niches[15]. Collecting different fish species from the wild can be suitable for households that are unable to access fingerlings but located in close proximity to water bodies. This approach especially targets remote and less wealthy fish farmers who are restricted by their physical and financial assets. Such approaches have been used in Bangladesh to promote women's access to highly nutritious fish in the household (see Castine et al. 2017).

Challenge	Availability of seed (fingerlings)
Objective	Improve household consumption, productivity and women's access to household ponds
Target groups	Poor fish farmers including women and youths
Location	Remote fish farmers who can access water bodies to collect wild fingerlings
Women and youths	Can allow greater inclusion of women and youths if promoted with interventions at the intra-household level
Specification	Identifying suitable species, biodiversity and considering biosecurity (*e.g.* fish disease)
Benefits	Improved nutrition security and income through additional sale of surplus fish

- Grow fish to smaller, acceptable size

It may be easier for smallholder farmers to grow tilapia to around 100-250 g, rather than the 400+ g tilapia produced by more intensive farmers. There are some advantages to growing smaller fish, such as faster cash flow as a result of shorter cycles and thus utilising fewer inputs. Poor consumers are able to afford smaller fish that are healthier since they are consumed whole. An analysis of markets and consumer preferences is required in order to assess the acceptance of smaller-sized fish. The pond economics of such interventions also require further

[15] This means that fish do not compete for food because they occupy different levels in the food chain or feeding areas (*i.e.* bottom feeders *versus* top feeders)

research. This could, however, be a niche that is exploited by smallholder farmers. This approach will probably require interventions at almost all levels, including production, value chain and household levels.

Challenge	Low growth rates
Objective	Grow smaller more nutritious fish for higher yields and larger profits
Target groups	Poor fish farmers, women and youths
Location	Remote fish farmers who cannot access commercial inputs and reach urban markets with their product
Women and youths	This intervention could be especially important for marginalised groups that struggle to access certain markets and inputs
Specification	Analysis of markets and consumer preferences required to assess acceptance of smaller-sized fish as well as pond economics of the profitability of growing such fish
Benefits	Better cash flow, poorer consumers are able to afford smaller fish, and improved nutrition through the consumption of small fish

7.2.2 Livelihood (asset-based) interventions

- Promotion of IAA systems

Integrated aquaculture agriculture (IAA) systems have can be a viable option for poor farmers who cannot afford commercial feeds. Such approaches sustainably utilise on-farm by-products as inputs in the pond and, in turn, irrigate crops with water from ponds. Undoubtedly this would cross over with interventions at the production level, however it is argued that it could encourage thinking outside of the pond system only, and introduce new livelihood options such as ducks, pigs, cattle or different vegetables to be grown on dykes. This is an intervention aimed at the "poorest of the poor" farmers who do not have the capital or assets to engage in aquaculture or be integrated in the value chain. In such interventions, a livelihood approach can be used and extra thought must be given to the social and cultural context. Many fish farmers in the present sample operate numerous and diverse small farming businesses, and ponds can be integrated into the whole

farm system. IAA systems can be implemented at more commercial and intensive levels too, and are linked to the first recommendation.

Challenge	Low productivity and access to commercial inputs
Objective	Improved pond productivity and total farm production through integration
Target groups	Poorest fish farmers who operate a wide range of different agricultural businesses (including livestock)
Location	Fish farmers who cannot access commercial inputs (due to location and/or costs/mobility)
Women and youths	Such approaches should be combined with intra-household approaches and promote fish farming as a household activity where division of labour is critical
Specification	Training on effective use of farm by-products and use of pond water for irrigation
Benefits	Improved nutrition security (through a diverse culture of agricultural and animal products) and income through sale

- Savings groups and microfinance

Many poor farmers, women and young people in particular lack the capital to enter aquaculture. Those who engage in aquaculture as one of many livelihood opportunities often do so in an environment characterised by risk and uncertainty and where there is a shortage of financial capital and other assets. Accessing various capitals, especially physical and natural capital, may be the catalyst that poor farmers need to engage in aquaculture more efficiently. Village savings groups or loans from microfinance organisations can allow farmers to make strategic choices on where and how to invest in aquaculture as one part of their livelihood portfolio. This intervention can be introduced in tandem with IAA systems as a means to expand people's livelihoods as a whole. This could be particularly relevant for young farmers who have limited farming opportunities.

Challenge	Limited financial capital
Objective	Investment in aquaculture and other livelihood strategies or assets to increase production and livelihood security

Target groups	Poor fish farmers, women and young fish farmers
	Better-off farmers could also look to upgrade their systems by attracting more investment
Location	Microfinance and loans will differ depending on farmers' assets, income levels and proximity to markets as well as their ability to pay back loans. Village savings groups may be more appropriate for rural farmers, while more formal loan programmes could be more appropriate for "better-off" farmers
Women and youths	Women and young people are often more limited in their access to financial capital and should thus be a critical target group for this intervention
Specification	Training on how to operate as a business is required. Some collateral may also have to be included.
Benefits	Access to finance allows for smarter investments in livelihoods and production systems

- Training material for different systems/needs

Training and knowledge is an important prerequisite (human capital) to be a successful fish farmer. Poorer, semi-subsistence farmers in the north who are isolated from the value chain require knowledge about how to better integrate their ponds into the whole farm system, whereas better-off fish farmers, who can access commercial inputs, may want to learn more about how to optimise their performance with such inputs. Some fish farmers in the southern region may need more knowledge about water quality management and how to exchange water in their ponds. New information and communication technologies (ICTs) should also be explored.

Challenge	Shortage of knowledge and skills on fish farming
Objective	Increases human capital and capacities
Target groups	Poor farmers: how to farm fish with minimal input costs
	Better-off farmers: how to best use commercial inputs, record keeping, entrepreneurial skills
Location	In areas where there is no access to commercial input,

	different training programmes are needed than in areas where there are better-off farmers who can access commercial inputs
Women and youths	Women and young people generally have less access to training materials and programmes
Specification	Training manuals and digital solutions such as training videos/podcasts/apps *via* phones can be used. Can be linked to farmer field schools (see below)
Benefits	Increased knowledge about pond management can increase total productivity

7.2.3 Value chain linkages

- Extension services by private-sector actors

Private-sector actors can try to gain a foothold in private extension services and provide basic training and input supplies to grow their market and/or develop grow-out projects. Agro-dealers and large feed companies, for instance, could visit and train farmers and in return get new customers for their aqua feed products. Such interventions may not always be suitable for all the "poorest of the poor" farmers in Zambia. The private sector may also be hesitant to assume the high risk and costs associated with such investments.

Challenge	Limited extension service
Objective	Dissemination of training and inputs and establishment of markets
Target groups	Better-off fish farmers
Location	Consider location and infrastructure and density of fish farmers. Such investments need to be a viable business opportunity for private sector actors. Intervention might not work if farmers are too remote or do not have purchasing power
Women and youths	Although greater inclusion of women and young people should be promoted, companies may be less willing to make these extra investments and so this might need to be facilitated by third-party actors (NGOs and government)

Specification	Training of farmers must create incentive for companies as they get new customers, *e.g. for* their aqua feed products
Benefits	Efficient extension services have the potential to boost production and improve the value chain linkages

- Common-pool resources: shared equipment

While attempts at forming cooperatives do not always achieve positive long-term results in aquaculture development, aspects of collective action are attractive for overcoming certain challenges, such as a lack of equipment or the high costs of transport. Resource pooling could be a good option for sharing the costs involved in production and marketing. Shared ownership of expensive tools such as nets, pumps or scales would mean that farmers could be more efficient and productive. For an individual household these items are not frequently used throughout the year. Depending on the scale and density of farmer clusters as well as their production and location, more advanced equipment in a central facility could be shared, such as fridges, basic water-testing kits or feed-processing machines.

Challenge	High cost of inputs and equipment
Objective	Improve pond management through collective action and resource-sharing
Target groups	Both poor and better-off fish farmers including women and young fish farmers
Location	Depending on the location, different tools may be required. Storage facilities can be developed if electricity is available and the sharing of nets or scales could be promoted in other areas
Women and youths	This could be a good option for women and young people to have access to certain assets and equipment
Specification	Shared ownership of expensive tools that are not used frequently
Benefits	Reduced costs for aquaculture business and lowers entry barriers

- Decentralised seed distribution models and other farmer-to-farmer outreach systems

To target the problem of limited seed availability in rural areas, more decentralised hatcheries are needed. These would be of great benefit to poorer farmers. As seen from this study's results, women may struggle to acquire inputs such as fingerlings because of the distances involved and travel constraints. This could be a solution that also enables more women to enter the sector. One intervention could be to train highly motivated fish farmers who are already experienced in fish farming to also breed fish. These farmers could be trained in rudimentary fingerling production methods and on how to distribute seed to fellow farmers in their locales. The same system can be applied to farmers who specialise in feed production. Small enterprises producing homemade fish feed (or manure/fertiliser) can be established in rural areas and feeds sold to farmers nearby.

Challenge	Availability of seed and feed
Objective	Improved access to fingerlings and feed by promoting local entrepreneurship
Target groups	Poorest fish farmers, women and youths, especially those in remote locations
Location	Types of species and proximity to existing inputs plays a large role in defining where such entrepreneurial models should be implemented
Women and youths	Since farmers with experience and assets are needed to develop hatcheries and feed mills, it would be difficult to always find women and young people who can do this. Care should be taken to do so. Entrepreneurs should be trained to also target women and youths for seed and feed sales
Specification	Experienced fish farmers need to be trained in basic fingerling (or feed) production for distribution to fellow farmers
Benefits	Especially for women who struggle to travel long distances to purchase fingerlings

- Sensitisation of financial services to improve access to credit

There is a lack of data on investment costs, profits and risks for fish farming businesses in Zambia. It is necessary to provide banks with economic data to explore opportunities to provide credit for fish farmers. As these results show, financial and physical capitals are crucial prerequisites to being a more successful and productive fish farmer.

Challenge	Banks do not give credit to aquaculture businesses
Objective	Improved access to credit
Target groups	Better-off fish farmers with collateral
Location	Consider location for investment costs and availability of commercial inputs and markets in calculations
Women and youths	There must be additional interventions to allow women and youths to access loans since banks are unlikely to specifically target these groups
Specification	Training on aquaculture as a business required. Provide bank with reliable data on farm productivity and risks regarding fish farming
Benefits	Improved financial assets help to produce more fish

- Clustering of farmers

It is difficult to access scattered farmers in remote areas and they are often isolated from the value chain. Clustering fish farmers in high potential areas will tackle a number of problems regarding inputs and outputs by incentivising collective action. With many farmers at one site there is a greater incentive for private companies to provide inputs such as feed and seed. Training can be better organised with larger groups, and farmers can be linked to markets. This recommendation fits with many other recommendations suggested in this section.

Challenge	Scattered farmers are isolated from the value chain
Objective	Improved access to inputs (including training) and output markets
Target groups	All fish farmers (poor and wealthy)

Location	High potential areas with suitable natural conditions for aquaculture and already existing infrastructure
Women and youths	Likelihood of there not being large samples of women and young people in potential cluster zones, therefore care must be taken to increase the participation of women and youths through social communication interventions seen below
Specifications	Clustering can be done by government or private companies by providing infrastructure and guarantee links to markets
Benefits	Improved input/output situation benefits productivity of farmers and thus contributes to income

- Inclusive business models - Contract farming

Contract farming is an attractive solution for farmers who are just starting out with fish farming. These farmers often lack the financial and physical capital to be able to make the investments needed for their new businesses, particularly women and young people. Such contract models have potential in areas in the south of Zambia where private companies are located and where those companies can supply and deliver farmers with inputs and knowledge. In turn, farmers pay back the input costs after harvest, either with their produce or the income made from the produce. The private companies collect and store the harvested fish and take care of sales at urban markets. In remote areas in the Northern Province, agro dealers can be used to distribute and sell inputs. There are a multitude of inclusive business models and more research is required to discover which ones are more appropriate to different groups and areas.

Challenge	Lack of finance, knowledge, skills and markets
Objective	Lowering entry barriers for fish farmers, increasing asset base and ultimately increasing productivity and linking farmers to markets
Target groups	Poor fish farmers, women and youths
	Better-off farmers can expand production and reach lucrative markets
Location	Consider location for contract farming, including proximi-

	ty to markets and input supplies (services)
Women and youths	Private-sector actors might not specifically consider including these groups and thus third party interventions may be needed
Specifications	Farmers are trained and supplied with inputs (sometimes on loan) and pay for these after the harvest
Benefits	Especially benefits women (who have challenges purchasing inputs) and youths (who often lack financial capital)

7.2.4 Intra-household (social/behavioural) interventions

- Social communication and behaviour change tools

Household interventions are usually those that seek to incentivise cooperation within households and/or between households, typically in a rural setting. They usually aim to be transformative in nature, looking to challenge any harmful social norms and beliefs. These can stem from issues around the roles of women to cultural beliefs around land tenure. Such issues usually have an unacknowledged impact on technology transfer, adoption and the general success of an intervention. In most cases, social communication and behavioural change tools should be complemented by other more technical interventions like those described above. Examples of interventions can be developing drama plays or posters that challenge harmful gender norms. Communication tools can look to challenge any pervasive beliefs that obstruct positive development impact, such as certain beliefs around consuming different foods for example. Typically, these types of interventions aim to boost the impact of other interventions and in general ensure the objective of promoting social wellbeing.

Challenge	Social and cultural constraints faced by marginalised groups
Objective	Challenge and transform harmful social norms and beliefs, especially around gender and youth participation in aquaculture
Target groups	Marginalised groups such as women and young people
Location	Location does not play a large role here though some areas (ethnicities) may have different social belief systems

	(*e.g.* matrilineal *versus* patrilineal societies)
Women and youths	While this mainly targets marginalised groups, it should also include those in power to foster change and cooperation
Specifications	Use of various communication tools (posters, dramas, video) to challenge certain norms
Benefits	Ensures social wellbeing and more inclusive growth of aquaculture, as well as having an indirect effect on development impact (*i.e.* increased productivity)

- Farmer field schools

Farmer field schools are an intervention at production level as well as household level. Farmer field schools provide hands-on training for fish farmers at demonstration sites. They are added here as household interventions because they would suit most Zambian fish farmers by promoting fish farming as a household activity that includes youths and women. The interested farmers and their families meet regularly at the demonstration site for a certain period of time to learn about pond management techniques and practices. Participatory action research techniques are used to ensure efficient knowledge, learning and feedback loops as well as to promote certain transformative social change interventions. These models have been shown to be successful in the past and can be applied in remote areas where a certain number of fish farmers are located. In remote areas, farmers rely more on horizontal networks, which could thus promote greater knowledge-sharing from farmer to farmer and wider dissemination.

Challenge	Lack of knowledge and training in households
Objective	Increasing equitable participation in aquaculture and access to knowledge and training by fostering cooperative atmosphere
Target groups	All households, especially poor households
Location	All locations appropriate, but particularly in remote rural areas where households engage in aquaculture
Women and youths	This approach has the potential to be very inclusive of women and young people and fosters greater acceptance and cooperation

Specifications	Training with demo sites and learning-by-doing methods while acknowledging certain social constraints
Benefits	Can increase productivity as well as cooperation in the household and between farmers

8 Conclusions

A Zambian-German research team conducted an international study to assess the opportunities and challenges presented by aquaculture for smallholder farmers in Zambia. The study was facilitated by development, research and government partners. The team found that aquaculture is a rapidly rising sector in Zambia and appears to be an attractive livelihood strategy for many people. Aquaculture has many direct benefits for farmers and the economy by boosting incomes through the sale of high-value products and increasing the availability of nutritious fish products. Aquaculture has a long tradition in Zambia, with smallholders adopting fish farming as part of a diversified livelihood. Although in recent years the commercial sector has created new opportunities for farmers to intensify production by accessing high-quality commercial inputs, many smallholders still operate extensive systems with relatively low production in isolation of these commercial developments. Understanding how small-scale farmers can upgrade their position in the value chain and further intensify their systems is a topic many stakeholders in Zambia are currently exploring, including the donor community, private sector and government.

It became clear in this research that traditional definitions such as "subsistence *vs*. commercial"; "extensive *vs*. intensive"; "large-scale *vs*. small-scale" only partly helps to characterise farmers in aquaculture. Age, gender, wealth and location (agro-ecological zones and proximity to markets or inputs) also have an effect on the status, performance and profitability of different farmers, further adding to the complexity. The main outcome of this research was to collect a wide array of data that would provide a better understanding of the sector to develop tailor-made recommendations for various target groups.

The central finding of this report stresses the multi-polarity of small-scale fish farming in complex livelihood systems. Given that there is a wide array of groups and multiple factors that can affect the success of how farmers engage in aquaculture, a multitude of recommendations are proposed. It is argued that there is no 'one-size-fits-all' approach, hence the recommendation to use our matrix as an analytical tool to assess farmer profiles and their opportunities and challenges. Researchers, policy-makers, private-sector actors and development practitioners can use this matrix to assess both challenges and opportunities, as well as to design interventions. The objective is to ensure that these actors include more holistic and systematic approaches to small-scale aquaculture development that do not exclude certain groups (women and youths) or ignore critical areas that re-

quire attention (*e.g.* household dynamics and social issues). While there are still many challenges for aquaculture in Zambia, especially for the benefit of poor farmers and consumers, the opportunities seem boundless. The agro-ecological conditions, the insatiable demand for fish and available markets, the institutions and policies that favour aquaculture production, and the willingness of thousands of farmers to adopt aquaculture into their livelihoods suggest that with the right adjustments to policies and development approaches and sustainable investments in the value chain, aquaculture could flourish and help alleviate poverty and increase food and nutrition security in Zambia.

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10 Annexes

Annex 1: SLE study team

Name	Position	Expertise
Alexander Kaminski	Team leader	Sociology and aquaculture
Dominik Giese	Junior researcher	Geography
Mara Gellner	Junior researcher	Fish biology
Azin Sadeghi	Junior researcher	Agriculture science
Sharif Jabborov	Junior researcher	Agricultural economics
Mario Lootz	Junior researcher	Political science
Nicolas Patt	Junior researcher	Social science – gender
Dr. Mary Lundeba	Independent consultant	Aquaculture science
Muzamba Siachinga	Research assistant	Geographic information systems
Boniface Nyika	Research assistant	Aquaculture science
Dr. Stefan Holler*	Consultant	Aquaculture science
Dr. Wiza Ng'ambi*	Consultant	Aquaculture science

* Consultants involved in the Eastern Province Study

Extended support team and cooperating partners

Name	Institution	Position for study	Expertise
Anja Kühn	SLE	Backstopper	Agriculture science
Dr. Silke Stöber	SLE	Backstopper	Agricultural economics
Dr. Alexander Kefi	DoF	Backstopper	Aquaculture science
Silke Uhlenbrock	WorldFish	Backstopper	Agricultural economics
Dr. Sven Genschick	WorldFish	Backstopper	Geography
Dr. Steve Cole	WorldFish	Advisor	Gender scientist
Moritz Heldmann	GIZ Zambia	Backstopper	Program coordinator

Annex 2: Asset Score

Capital	Indicator	Attribute	Unit	Category or value					Points (max.)	Points (received per category)	Points (total received)	Points (total)
Human	Agricultural skills	Farming experience	Years	> 20 years [3 points]	11-20 years [2 points]	5-10 years [1 point]		< 5 years [0 points]	3 pts max		/10.5 pts.	10.5 pts.
		Training received	Number	> 5 [2 point]	3 to 5 [1 point]	1 to 2 [0.5 points]		None [0 points]	2 pts max			
	Education	Level of education	Highest level	Tertiary [2 point]	Secondary [1.5 points]	Basic [1 point]	Primary [0.5 points]	None [0 points]	2 pts max			
		Literacy	Share	All adult hh members [1.5 points]	More than one, but not all [1 point]	One [0.5 points]		None [0 points]	1.5 pts max			
	Labour force	Dependency ratio	Non-contributor per contributor	<= 0.5 [2 points]	0.51 - 1 [1 point]	> 1 [0 points]			2 pts max			
Social	Relationship with extension officer	Quantity of exchange	Regularity	Everyday [2 points]	Every week [1.5 points]	Once a month [1 point]	Less than once a month [0.5 points]	Never [0 points]	2 pts max		/9 pts.	9 pts.
		Quality of relationship	Perception	Good [1 point]	Poor [0 points]	No relationship [0 points]			1 pt max			
		Access to information	Form of access	Direct communication [1 point]	Indirect communication [0.5 points]	No access [0 points]			1 pt max			

	Relationship with village head	**Quantity of exchange**	Regularity	Everyday/I am the village head [2 points]	Every week [1.5 points]	Once a month [1 point]	Less than once a month [0.5 points]	Never [0 points]		2 pts max				
	Participation in organisations	**Farmer organisations**	Membership	Yes [1 point]	No [0 points]					1 pt mx				
		Social organisations	Membership	Yes [1 point]	No [0 points]					1 pt mx				
	Urban linkages		Form of linkage	Live in urban area [1 point]	More than one relative [0.75 points]	One relative [0.5 points]		No relatives [0 points]		1 pt mx				
Financial	**Income**	**Farming income**	Kwacha	> 50000 [2 points]	50000 - 25000 [1.67 points]	25000 - 10000 [1.33 points]	10000 - 5000 [1 point]	5000 - 3000 [0.67 points]	3000 - 1000 [0.33 points]	< 1000 [0 points]	2 pts max		/11 pts.	11 pts.
		Non-farm income	Kwacha	> 50000 [2 points]	50000 - 25000 [1.67 points]	25000 - 10000 [1.33 points]	10000 - 5000 [1 point]	5000 - 3000 [0.67 points]	3000 - 1000 [0.33 points]	< 1000 [0 points]	2 pts max			
	Investment	**Investments in farm**	Kwacha	> 50000 [2 points]	50000 - 25000 [1.67 points]	25000 - 10000 [1.33 points]	10000 - 5000 [1 point]	5000 - 3000 [0.67 points]	3000 - 1000 [0.33 point]	< 1000 [0 points]	2 pts max			
	Credit availability	**Capability**	Type of credit	Bank credit [2 points]	Saving group [1 point]	Informal loan [0.5 points]		None [0 points]		2 pts max				
	Remittances	**Availability**	Last year in last year	Yes [1 point]	No [0 points]					1 pt max				
	Labour supply	**Hired labour**	Form of hired labour	Permanent and seasonal [2 points]	Permanent [1.5 points]	Seasonal [1 point]		None [0 points]		2 pts max				
Natural	**Land allocation**	**Total land area owned**	Acres	> 50 ha [3 points]	21-50 ha [2.5 points]	11-20 ha [2 points]	5-10 ha [1.5 points]	2-4.9 ha [1 point]	< 2 ha [0 points]	3 pts max		/11 pts	11 pts.	

		Form of land owner-ship	Title	Formal title [2 points]		Informal tenure [1 point]		No land owned [0 points]		2 pts max			
		Land use	Percentage	All used [2 points]	More than half [1.5 points]		Less than half [1 point]		None [0 points]	2 pts max			
		Water availa-bility	All year	Yes [2 points]		No [0 points]				2 pts max			
	Livestock	**Animals**	Tropical Livestock Unit	> 50 [3 points]	10.01-50 [2 points]	5.01-10 [1.5 points]	1.01-5 [1 point]	0.5-1 [0.5 points]	< 0.5 [0 points]	3 pts max			
Physical	**Housing**	**Walls**	Material	Brick and cement [2 points]		Brick and mud [1 point]		Pole and mud [0 points]		2 pts max		/13 pts.	13 pts.
		Roof	Material	Corrugated iron [1 point]		Straw [0 points]				1 pt max			
		HH member / bed-room	Number	< 2 [1 point]		2 [0.5 points]		> 2 [0 points]		2 pts max			
		Electrici-ty supply	Source	ZESCO [2 points]	Generator [1.5 points]		Solar panel [1 point]		No electricity [0 points]	2 pts max			
		Water	Source	Private [2 points]	Shared improved [1.5 points]		Natural protected [1 point]		Unprotected water source [0 points]	2 pts max			
	Produc-tive equip-ment	**Agricul-tural tools**	Endowment	Advanced [2 points]		Medium [1 point]		Basic [0 points]		2 pts max			
	Means of transpor-tation	**Availa-bility**	Kind of	Car [2 points]	Ox cart [1.5 points]		Motorcycle [1 point]	Bicycle [0.5 points]	None [0 points]	2 pts max			

Annex 3: Farm score

Criteria		Points
Feed	No feed	0
	Vegetables	2
	Maize bran	3
	Homemade feed	4
	Commercial	6
Frequency of feeding	Not daily	1
	Daily	3
Fertilizer	No fertiliser	1
	Manure	2
	Chemical	4
Source of seed	Wild, recycled, fellow farmers	0
	Government hatcheries	2
	Private hatcheries	6
Poly/monoculture	Polyculture (mixed tilapia)	0
	Monoculture	3
Use of fish	Home consumption	1
	Selling	3
Type of fingerling	Do not know	0
	Mixed sex	2
	Sex-reversed	5
Stocking density	Do not know	0
	Low (1-3 fish/m^2)	2
	Medium (3.5-5 fish/m^2)	4
	High (>5 fish/m^2)	6
Record keeping	No	0
	Yes	2
Buy fingerlings	No	1
	Yes	6
Equipment	Nothing	1
	Basic	2
	Medium	4
	Advanced	6
Harvest strategy	Partial	0
	More than 7 months	2
	6-7 months	3
Total score		Between 5 and 53

Annex 4: Gross margin analysis

Detailed GMA of the case study of fish farmers in Southern Province (ID: S2M)

1. General information (ID: S2M / DG01)							
Province	**District**	**Pond number**	**Pond size**	**Density**	**Production cycle**	**Fish species**	**Production last cycle** (t*)
Southern	Choma Town	3	840 m^2	5	7 months	*Andersonii, Rendalli*	352 kg

*t - total fish production in the last production period

2. Inputs					
	Unit	**Quantity**	**Unit cost (ZMW)**	**Cash value (ZMW)**	**Non-cash value (ZMW)**
Fingerlings	amount	7,000	0.21	1500	0
Transport (buy fingerlings)				0	0
Commercial Feed	kg	150	5	750	0
Homemade feed	kg				
Regular feed (maize bran)	kg	450	0.9	0	405
Animal manure	50 kg bags	5	20	0	100
Green manure	kg				
Medicines					
Lime					
Water					
Electricity					
Other:					
Total:				a 2,250	b 505
Total value of inputs: c = a + b				c 2,755	

2.1 Labour				
	Number	**Cost/labour/ day**	**Cash value**	**Non-cash value**
Fixing fish pond				
Feeding	1 h/day	5.07	0	993
Harvesting		300	300	0
Transportation to a market				
Other:				
Total:	d 213 h		e 300	f 993
Total value of labour: g = e + f			g 1.293	
Total input costs: h = a + e (cash); i = b + f (ncv*)			h 2,550	i 1,498
Total value of input: j = h + i			j 4,048	

* non-cash value (ncv)

3. Outputs					
	Unit	**Quantity**	**Unit cost**	**Cash value**	**Non-cash value**
Fingerlings sold	number	6.000	1	6,000	0
Fish sold	kg	100	10	1,000	0
Fish consumed by family	kg	252	30*	0	7,560
Fish given to other people	kg				
Fish exchanged with other	kg				
Fish in the stock					
Other:					
Total:				l 7,000	m 7,560
Total value of outputs: o = l + m				o 14,560	

Economic calculation		
Profit and/or loss	**Calculation formula**	**Value**
Cash balance	p = l - h	p 4,450
Gross margin	q = o - j	q 10,512
Gross margin in percent	GM (- non-cash value): p / l x 100 GM (+non-cash value): q / o x 100	GM (-ncv): 64 % GM (+ncv): 72 %

1) Calculation with labour costs (cash and non-cash) and all non-cash values			
Analyses of profit per unit of Input	**Calculation formula**	**Value**	
Gross margin / hour of labour	r = q / d	r	49.4
Gross margin / kg Fish	s = q / t*	s	29.9

2) Calculation without all non-cash values			
Analyses of profit per unit of input	**Calculation formula**	**Value**	
Gross margin / hour of labour	r = p / d	r	20.9
Gross margin / kg fish	s = p / t*	s	12.6

3) Calculation without any labour costs but with non-cash values from sold fish			
Analyses of profit per unit of input	**Calculation formula**	**Value**	
Gross margin / hour of labour	r = o / d	r	68.4
Gross margin / kg fish	s = o / t*	s	41.4

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